Temporal Drivers of Disaster Risk and Resilience in Rural New Zealand

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A thesis submitted in fulfilment of the requirements for the Degree

of

Master of Science in Disaster Risk and Resilience

by

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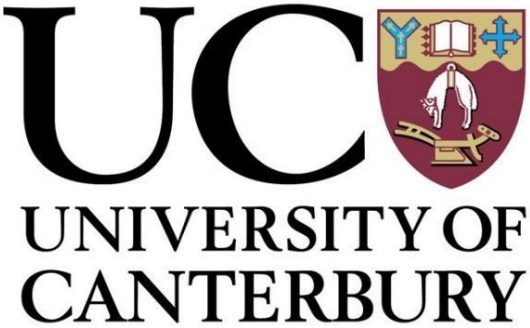

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FRONTISPIECE

Top of the Mangamingi Saddle, Rawhitiroa, South Taranaki. In the distance lies Taranaki Volcano, in the foreground, a sheep and beef farm.

ABSTRACT

Aotearoa-New Zealand's rural communities are an essential part of the nation's economy, society and culture. They face challenges to their resilience including impacts of hazards like drought and earthquakes, alongside the compounding impacts of social, cultural and economic change. Significant, temporal change to rural communities impacts their resilience to future disruption, however more research is needed to understand the drivers of changing disaster resilience in these communities. These gaps could lead to issues in future policy, rural development and disaster risk management and contribute to an information poor decision making environment.

The aim of this research is to draw together a cohesive summary that investigates the drivers and outcomes of rural disaster risk and resilience over multiple dimensions in the rural sector. This involves addressing the following objectives; Identify temporal drivers of change in rural communities, identify available data that can be used to characterize these drivers, and evaluate the impacts of a dynamic, changing rural environment on rural disaster resilience. To achieve these objectives, a review of rural literature, and New Zealand data was undertaken to gather rural indicator datasets. These indicators were visualised, primarily using geospatial analysis. The results are discussed through the lens of the Treasury Living Standards Framework, to quantify the potential impacts of this change on disaster resilience.

The methodological findings of this thesis reveal that the availability and quality of data for rural decision makers is challenged by the nature of rural research and data collection in New Zealand. Additionally, available data does not currently reflect the true nature of New Zealand rural communities. The findings of this research reveal that rural communities in New Zealand have undergone significant change in the past 50 years. Key changes such as demographic shifts, land use change, and long term, multi-dimensional impacts from service rationalisation, such as the closure of schools and medical centres have impacted the disaster resilience of New Zealand's rural communities.

The findings of this research provide lessons for exploring future rural disaster resilience and outline the need to develop more effective systems for utilising, collecting and analysing research data, alongside addressing the changing nature of rural New Zealand to improve future rural policy and disaster decision making.

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LIST OF ACRONYMS

CDEM	Civil Defence and Emergency Management
DRR	Disaster Risk Reduction
GFDRR	Global Facility for Disaster Risk Reduction
GIS	Geographic Information System
MBIE	Ministry for Business, Innovation & Employment
MCDEM	Ministry of Civil Defence & Emergency Management (now NEMA)
MPI	Ministry for Primary Industries
NDRS	National Disaster Resilience Strategy
NZDS	New Zealand Data Strategy
NEMA	National Emergency Management Agency
OECD	Organisation for Economic Cooperation & Development
RNC	Resilience to Nature's Challenges
UNDRR	United Nations Office for Disaster Risk Reduction

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Context of Research

The Global Facility for Disaster Reduction and Recovery (GFDRR) estimates that disaster impacts are increasing globally, with greater loss, and higher levels of damage than in the past, from $50 billion annually in the 1980s, to $400 billion annually in the last decade (GFDRR, 2018). This is attributed to dynamic changing hazard, exposure and vulnerability. Past efforts to reduce the impacts of disasters disproportionately focused on hazards as natural and unavoidable disasters (Galliard & Mercer, 2013; Prevention Web, 2015). Accordingly, for much of the last 100 years, management and mitigation approaches to disasters have largely been top-down 'technocratic' solutions (Allen, 2006). However, while often triggered by natural hazards, disasters occur when the intersection of multiple factors (vulnerability and exposure of people and assets), interact with a hazard, and the associated impacts of this interaction exceed the capacities of people, communities and societies to function (UNISDR, 2009) (now UNDRR).

Following the development and implementation of the Hyogo Framework in 2005, later superseded by the Sendai Framework in 2015, disaster risk reduction (DRR) began to move toward a more proactive, resilience based approach. This approach aims to produce more positive post-disaster outcomes by acknowledging that drivers of risk and resilience are controlled by policy makers, individuals and communities (GFDRR, 2018). This shift from a reactive disaster response approach, to a proactive resilience based approach has driven extensive DRR research in the last few decades (Innocenti & Albrito, 2011).

While the role of communities post disaster is becoming increasingly recognised (Cutter, Ash, & Emrich 2016), Vallance and Carlton (2015) identify that pre disaster understanding of the resilience of these communities is still poorly understood. Therefore, decision-makers require a more comprehensive picture, incorporating both

risk management and the enhancement of societal resilience, to fully achieve DRR (Helm, 2015).

Whilst a broad base of research has emerged over the past few decades in urban resilience and disaster risk (Flint & Luloff, 2006; Pelling, 2003; Leichenko, 2011), rural disaster research is less prominent in the literature (Cutter et al., 2016). A large proportion of global research is focused on rural disaster risk in developing countries. In the Sendai Framework, priority areas of focus emphasise managing the resilience of marginal rural settings, such as those of developing countries through land use planning and management (Pica, 2018; Sendai Framework, 2015; Prevention Web, 2015). Research focused on rural areas in more developed countries, and the specific characteristics that influence their disaster risk and resilience, is less extensively covered (Cutter et al., 2016). Additionally, the disaster resilience of rural communities is often overlooked in favour of larger urban societies (Smith et al., 2011).

Significant, long-lasting changes to the fabric of rural communities drives changes in their resilience to future disruption (Whitman et al., 2013). The consequent implications of changing resilience in these communities is not currently well captured (Fielke, Kaye-Blake & Vibart, 2017; Cutter et al., 2016; Spector, Cradock-Henry, Beaven & Orchiston, 2019). There is a need to evaluate the underlying drivers of community resilience and dynamic drivers of change, to better inform rural resilience and future disaster risk (Kwok et al., 2016). It is critical to address the drivers of rural disaster resilience, as these areas present different challenges than urban areas for disaster management practitioners, policy makers, and community members themselves (Kapacu, Hawkins & Rivera, 2013).

1.2 Drivers of Rural Resilience

A changing rural environment drives changes in rural resilience, however the varied and often subtle nature of this change means that it can be difficult to discern high level factors that may influence community resilience (Race, Luck & Black, 2010;

Lockie, 2000; McManus et al., 2012). This also makes comparative rural research challenging as research is context specific and can be hard to generalise (Howie, 2008).

Several factors contribute to the lack of clarity surrounding drivers of rural disaster risk and resilience. Many community resilience processes rely on data for assessment, both primary data collection and the use of existing secondary data (such as census data). In practice, accessing the quality and quantity of data needed for meaningful analyses can be difficult (Kay et al., 2019). There is often a significant gap between what resilience data is needed and what can be measured. Additionally, Stevenson et al. (2017) note that the use of data for resilience based work in New Zealand can be hindered by issues of inefficiency and knowledge gaps.

While a large amount of data is collected in New Zealand, its use and application can be hindered by issues of accessibility, availability, duplication, and usability. Data collection is undertaken in many different ways and stored in many different formats. Whether is fit for purpose depends on key factors, such as data resolution, accuracy and accessibility, and frequency of measurement. Disconnects often occur between what end users of information need and what providers of data are delivering, as well as issues of duplication of data across multiple agencies (LINZ, 2016). Additionally, data can be stored in formats that are inaccessible without technology or expertise. Rapid advancements in data growth and technology (such as the development of GIS) have also changed the research data landscape. However, significant value can be added to the socio-cultural, environmental and economic fabric of New Zealand through the effective use and application of data (LINZ, 2016).

Another factor that contributes to the lack of clarity around rural disaster resilience drivers is the nature of the disaster risk reduction (DRR) environment. Spector et al. (2018) noted that despite the relatively small size of the rural research community in New Zealand, many of the research outputs remain siloed within institutions and agencies. Disciplinary and organisational silos have been identified as working against

building resilience (Bryner, Norris & Fleming 2012; Fenwick, Seville & Brunsdon, 2009).

Additionally, the application of scientific knowledge in DRR relies on the engagement of practitioners in scientific research, which can be difficult to understand and user unfriendly (Edwards et al., 2012). Additional challenges to engagement include the challenges of understanding risk and scientific uncertainty, different perspectives of stakeholders and the capacity of stakeholders to meaningfully engage with research (Edwards et al, 2012). As a result, natural tensions between research and policy application exist, particularly around separate goals of scientific accuracy and political relevance (Beaven et al., 2016). Dialogue between science and policy requires effective communication, and the communication of science for disaster risk reduction is vital for scientific information to be applied (Bryner et al., 2012). Effective DRR communication is also required to move away from a siloed disciplinary approach, and improve the accessibility of data such as through transferring it to different formats (Bryner et al., 2012; Chmutina & Bosher, 2015). These challenges contribute to an information poor environment for rural decision makers, from the government, to the community level. Understanding the drivers of changing rural disaster resilience allows decision makers to transition knowledge into meaningful action for DRR (Weichselgartner & Kelman, 2014).

Determining disaster resilience drivers should always be reduced to a methodological problem, given that DRR operates within a complex system of responsibilities and governance (Prior & Hagmann, 2012). Cutter (2016) notes that there is no one tool to measure disaster resilience, due to the complexity of definitions, environments and disciplines, but that the methodological approach should be a function of the goals of the resilience assessment. To this end, a high level 'synthesis' of rural knowledge, research and data has been utilised, to best understand the complex drivers of disaster resilience in rural communities.

1.3 New Zealand's Rural Landscape

New Zealand's rural communities are an essential part of the nation's economy, society and culture (Spector et al., 2018). Rural communities occupy a dominant place in the cultural fabric of New Zealand, in part because agricultural production is the predominant economic base for many regional areas (Patterson et al., 2006; Spector et al., 2018). Rural areas are not homogenous in composition but rather, are shaped by changing external conditions such as migration and urbanisation, and consist of diverse groups, including farmers, agricultural and non-agricultural workers as well as semi-urban 'life-stylers', comprising almost 14% of the population (Pink, 2004; Fraser, 2006; Maguire & Hagan, 2007; Smith et al., 2011).

In New Zealand, rural communities have faced change in multiple dimensions - influenced by large scale, exogenous forces, and socio-economic shifts, such as population drift to urban areas and subsequent demographic change (Smith & Montgomery, 2004; Pink, 2004; Burton & Peoples 2014; Flint & Luloff, 2006; Pomeroy, 2015; Pomeroy & Newell, 2011; Leichenko & O'Brien, 2002). Additionally, rural policies commonly equate the needs of rural communities with the needs of the agricultural sector, but this doesn't always reflect the varied groups in these areas (Pomeroy & Newell, 2011; Liepins, 2000; Scott, Park & Cocklin, 2000; Joseph, Lidgard & Bedford, 2001).

Situated on an active plate boundary between the Pacific and Australian tectonic plates, New Zealand is subject to a range of natural hazards including earthquakes, tsunamis and volcanic eruptions. Alongside this is a long history of meteorological events and associated impacts including flooding, landslides, coastal erosion and storms, severe winds, snow, and drought (Glavovic, Saunders & Becker, 2010). The nature of this hazard context drives the need for informed disaster risk reduction and policy making. Spector et al. (2018) note that rural New Zealand has faced repeated challenges from exposure to hazards including climatic variability, droughts, floods, and earthquakes (Cradock-Henry, 2017; Harrington et al., 2014; Lawrence et al., 2013; Stevenson et al., 2017; Stroombergen et al., 2006). These challenges have ongoing impacts for rural communities, productivity and the economy.

DRR and resilience research informs both government policy and research programmes in New Zealand, with a strong emphasis on the co-creation of resilience between governing bodies, private entities, NGO's and communities to inform disaster risk management at all levels (Fraser et al., 2016). New Zealand's DRR landscape is hallmarked by a strong culture of investing in disaster risk reduction to improve resilience through the 4R's; reduction, readiness, response and recovery (Rotimi, Masurier & Wilkinson, 2006). The statutory framework for disaster risk and resilience is implemented by the National Emergency Management Agency (NEMA) underpinned by the Civil Defence Emergency Management (CDEM) Act 2002 (Dantas & Seville, 2006). NEMA sets out the direction for regional and district level Civil Defence and Emergency Management (CDEM) groups in New Zealand. Core additional legislation presented in Figure 1.1 includes the Resource Management Act 1991, the Local Government Act 2002 and the Building Act 2004, all of which contribute to a holistic framework of DRR (McNaughton & Van Hove, 2014; MCDEM, 2019).

Figure 1.1 The Legislative Environment of the National Disaster Resilience Strategy (NEMA, 2019)

In 2015, New Zealand signalled commitment to the Sendai Framework for Disaster Risk Reduction 2015-2030 (hereafter the Sendai Framework), as a part of its strategy

of enhancing resilience and reducing disaster risk (Saunders et al., 2020; Basher, 2016; Pica, 2018). The Sendai Framework was developed by the United Nations Office for Disaster Risk Reduction (UNDRR), predated by the Hyogo Framework 2005 - 2015. The Framework aims to coordinate global disaster risk reduction efforts by fostering coherence in reducing risk, improving resilience and improving the outcomes of hazard impacts on communities. Four main priorities underline the Sendai Framework (2015):

1. *Understanding disaster risk.*
2. *Strengthening governance to manage disaster risk*.
3. *Investing in disaster risk reduction for resilience.*
4. *Enhancing preparedness for effective response and to build back better in recovery.*

The Sendai Framework recognises that governments play a primary role in disaster risk reduction, and that this responsibility is shared with key stakeholders including researchers, local governments, communities, and the private sector (Pica, 2018). To achieve this, it emphasises a move toward addressing the exposure, vulnerability, capacity and resilience of communities to address disaster risk (Aitsi-Selmi et al., 2015).

Disaster risk is a function of three components: hazard, exposure and vulnerability (GFDRR, 2016). These are essential components of disaster risk, a foundational aspect of DRR and dynamically evolve over time, both naturally and through human activity (UNDRR, 2017). Changes in these components influence other components and contribute to changes in overall risk (GFDRR, 2016). A risk based approach is fundamental to DRR. DRR is operationalised through disaster risk management (DRM), and these are linked by disaster risk assessment (DRA). DRR literacy is vital for informed policy, and for decision makers to be cognizant of where gaps are. Key definitions for these terms are provided in appendix A.1. Davies et al. (2015) argue that limited integration of science in DRR policy, planning and practice hinder effective DRR.

The Sendai Framework was a key influence in the development of the National Disaster Resilience Strategy (NDRS) which came into effect in April 2019. It replaced the previous National Civil Defence Emergency Management Strategy and was released by the Ministry for Civil Defence and Emergency Management (MCDEM), now the National Emergency Management Agency (NEMA). The Strategy sets out the long term aims and vision for civil defence and emergency management in New Zealand. It is the third strategy delivered under the CDEM Act and is intended to provide a common platform for resilience that individuals, agencies and organisations can align with, reflecting the integrated nature of New Zealand's DRR landscape (MCDEM, 2019).

The NDRS aims to:

- *Promote the sustainable management of hazards.*
- *Encourage participation particularly at the community level in processes of managing risk.*
- *Provide planning and preparation for emergencies, response and recovery.*
- *Provide a basis for the integration of national and local planning and activity through a national strategy.*
- *Encourage coordination in DRR across a wide range of agencies.*

The Strategy acknowledges that rural environments have different resilience challenges to their urban counterparts, for example, rural populations can be dispersed across less accessible landscapes, and more dependent on critical lifelines infrastructure such as power transmission lines or telecommunications towers (MCDEM, 2019). A key goal of the NDRS is that disaster management works with the particular *"challenges, needs, preferences, capabilities and aspirations of rural communities"* (MCDEM, 2019). Despite acknowledging differences between rural communities and their urban counterparts, the Strategy does not explicitly identify drivers of differences in rural and urban disaster resilience, how these are changing over time, and how they will change in the future.

However the Strategy does have a focus on the long term wellbeing of communities. To achieve this, the strategy links intergenerational wellbeing with risk management and resilience stating that; *"It is explicit that the purpose of resilience be the protection of wellbeing and prosperity"* (MCDEM, 2019). This focus on wellbeing guides the Strategy, by addressing underlying drivers of change, as well as building the capacity to manage change, which in turn will reduce impacts, disaster risk and foster development and growth (MCDEM, 2019).

The wellbeing vision is outlined in Treasury's Living Standards Framework (LSF). The framework is used to analyse the impacts of policy on intergenerational wellbeing and is framed by four capitals: natural, human, financial/physical and social capital (Figure 1.2). The LSF builds on the Organisation for Economic Cooperation and Development's (OECD) wellbeing approach, with a dashboard that aims to capture a comprehensive range of wellbeing indicators. This framework helps to inform government priorities, policy decisions, and investment (New Zealand Treasury, 2018). The goal of the LSF is to enhance natural, social, human and financial/physical capital to improve the wellbeing of communities (Frieling & Warren, 2018). The NDRS links to the Living Standards Framework (LSF), noting that resilience and risk management are imperative for wellbeing and considering ways to improve resilience across the four capitals of the LSF. Whilst it has a temporal focus on change, the Living Standards Framework could be difficult to apply in rural communities where data for tracking rural capitals could be difficult to find and utilise.

Figure 1.2 Treasury's Living Standards Framework (New Zealand Treasury, 2018)

While the legislative framework for DRR is driven by a number of different actors, implementation is carried out by local government and communities. Reflecting the nature of DRR legislation in implementation is a key challenge, particularly in places with smaller populations in hazard prone areas, like rural communities. Improving this involves making use of collaborative strategies between local and central government, the private sector and community stakeholders (McNaughton & Van Hove, 2014). Therefore, rural decision-makers require a more comprehensive approach, incorporating both risk management and the enhancement of societal resilience, to fully achieve DRR (Helm, 2015). A cohesive summary that investigates the drivers and outcomes of rural disaster risk and resilience over multiple dimensions in the rural sector, could form a powerful communication and decision-support tool for rural communities, researchers and disaster decision-makers (Spector et al., 2017).

Recent disaster examples, from both Kaikōura and Manawatu-Wanganui, illustrate the need to understand drivers of rural disaster risk and resilience. In 2004, major flooding

of the Manawatu River resulted in it reaching its highest level in 100 years, heavily impacting the Manawatu-Wanganui region (Smith et al., 2011). Infrastructure and housing were all heavily impacted, including areas that had not seen flooding in living memory. Many rural communities were unaware of impending flooding and were badly affected by property damage and major losses in equipment and livestock, severely affecting farm production (Smith et al., 2011). Research indicates this event had significant, long lasting impacts on the local rural community. Smith et al. (2011) link these impacts to the *"hollowing out"* of rural New Zealand; where changes in the traditional rural community structure of years past (such as through migration), or changes in farming practice, and the implications of this on community disaster resilience, was not realised until the 2004 flood event.

In 2016 the small community of Kaikōura, New Zealand, was struck by a magnitude 7.8 earthquake. Significant damage, including to infrastructure such as roads, impacted the agriculture and tourism dependent Kaikōura economy, with estimates for rebuild reaching as high as NZD$3 billion (Cradock-Henry, Fountain & Buelow, 2018). The earthquake and associated co-seismic hazards (such as landslides) posed significant challenges for the community and disaster response. Due to the inaccessibility of roads for milk tankers, twenty-four dairy farms in the district had to dump thousands of litres of milk a day for several weeks (Cradock-Henry et al., 2018). Damage to roads also impacted the flow of tourists throughout the region, undermining a valuable source of revenue. The Kaikōura Earthquake event highlighted the vulnerabilities of its rural community, indicating a need for strengthening understanding of and preparation for disaster resilience in a changing rural context (Stevenson et al., 2017; Wilson & Simmons, 2017; Cradock-Henry et al., 2018). These events highlighted both the vulnerabilities and resilience of New Zealand's rural sector, and have focused attention on a vision of a 'resilient rural New Zealand', a theme which underpins government policy at the local, regional and national levels (Hayward, 2013; Spector et al., 2018).

Internationally it is well recognised that significant, long-lasting changes to the fabric of rural communities impacts their resilience to future disruption, however the

consequent implications of changing resilience in these rural communities is not currently well captured (Cutter et al., 2016; Fielke et al., 2017; Spector et al., 2018; Whitman et al., 2013). Kwok et al. (2016) note that there is a need to evaluate the underlying drivers of community resilience and dynamic drivers of change, to better inform rural resilience and future disaster risk. These gaps could lead to issues when informing future rural policy, decision making and disaster risk reduction.

1.4 Purpose of Research

The purpose of this thesis is to assess the impacts of dynamic, temporal change on the resilience of rural communities in New Zealand. The outcome of this research will provide a clearer understanding of the extent and impacts of change in rural New Zealand in multiple dimensions. This will improve understanding of the drivers of past, present and future disaster resilience in rural New Zealand communities.

The objectives of this research are to:

1. Identify temporal drivers of changing rural disaster resilience.
2. Identify data that can be used to characterize drivers of rural disaster resilience.
3. Evaluate the impacts of a dynamic changing rural New Zealand environment on rural disaster resilience.

1.4.1 Thesis Structure

This chapter, *Chapter 1,* establishes the context for the thesis, firstly through an overview of the research and hazard context of rural New Zealand. This is followed by an outline of the research methodology for this thesis. The final section of this chapter is a review of global and New Zealand DRR.

Chapter 2 addresses objective 1; *identify indicators of changing resilience in rural New Zealand communities.* Firstly, through a review of existing global research, with a focus on identifying drivers of change in rural communities. This is followed by a review of New Zealand rural literature. This process informs the development of four

broad categories of rural change; societal, economic, environmental and technological.

Chapter 3 addresses objective 2; *identify data that can be used to characterize drivers of rural disaster resilience*. The first section of this chapter presents an introduction to indicator datasets and a review of the research data landscape in New Zealand, this is followed by an outline of data quality parameters used to guide the selection of data. The second section of this chapter is a review of available data in New Zealand, and presents selected rural disaster resilience indicator datasets.

Chapter 4 presents the visualised indicator datasets, such as land use and demographic change, grouped by environmental, societal, environmental and technological trends.

Chapter 5 addresses objective 3; *evaluate the impacts of a dynamic changing rural environment on rural disaster resilience.* The first section of this chapter evaluates rural change in New Zealand, through the lens of the Living Standards Framework Capitals and provides recommendations for future research. The second section of this chapter is a broader discussion of the methodological limitations and findings of this research, including the challenges of using indicator data. This is followed by an evaluation of the impacts of rural change on disaster resilience and recommendations for future research.

Chapter 6 summarises the findings of the research project, and presents recommendations and future work.

1.4.2 Research Methodology

The objective of this section is to outline the research methodology for the thesis. The methodology synthesises a combination of approaches. The methodology brings together a review of resilience literature and a review of rural data to identify indicator datasets of rural change. These datasets are visualised and analysed primarily through

GIS. These results are then discussed through the lens of the Living Standards Framework capitals. The methodology structure is presented in Figure 1.3.

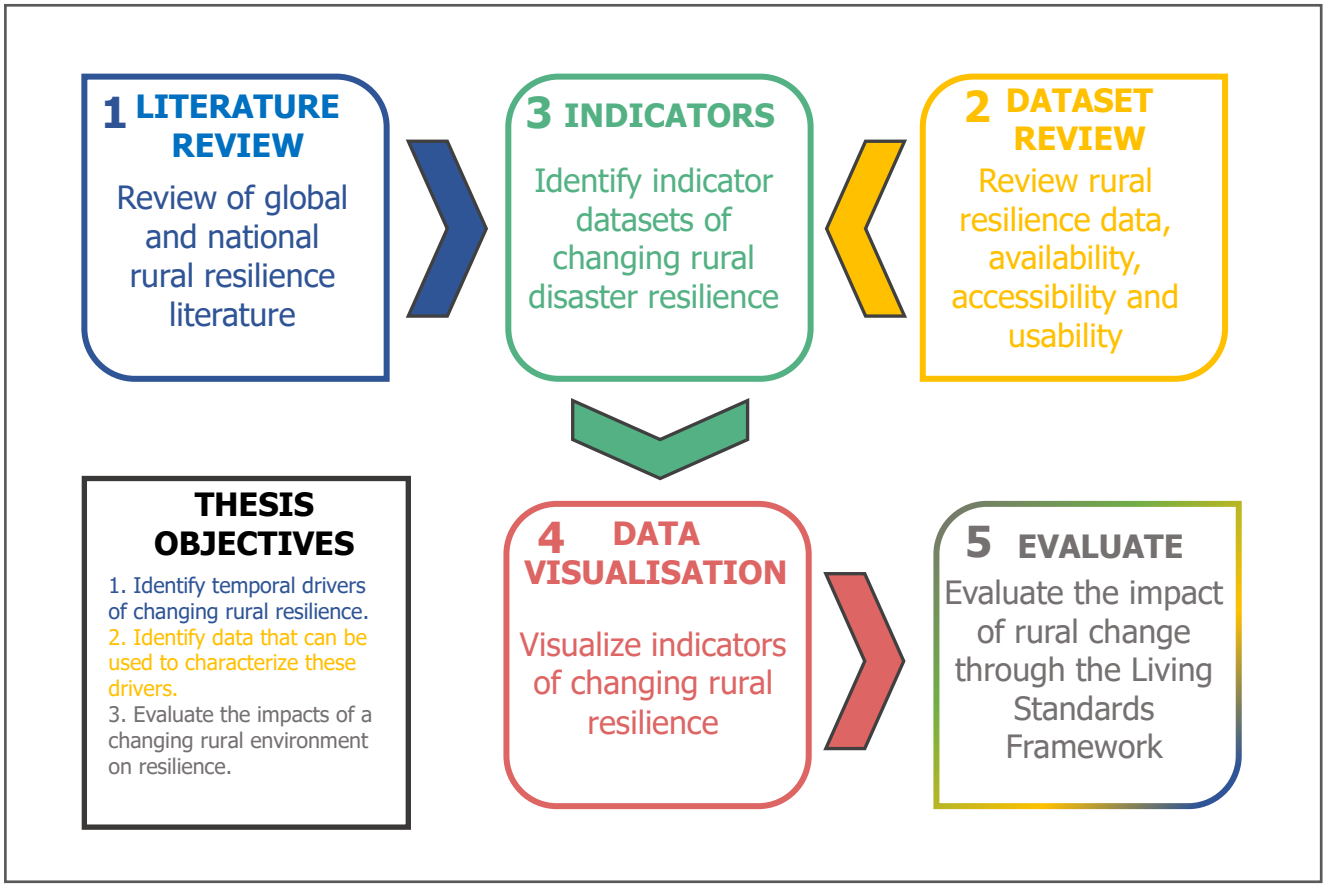


Figure 1.3 Research Methodology

1.4.2.1 Review of Rural Literature

The first stage in the methodology is a literature review. This review is used to contextually ground the research in a way that ensures any outputs will be useful, usable, used, and highlights potential priority areas of focus, informing the methodology and framing the rest of the research.

The literature review addresses objective 1; *Identify temporal drivers of changing rural disaster resilience*. Firstly, through a review of existing global research, with a focus on identifying drivers of changing resilience in rural communities. This is followed by a review of New Zealand rural literature. This process informs the development of four

broad categories of rural change; societal, economic, environmental and technological.

1.4.2.2 Review of New Zealand Data

The data review stage addresses objective 2; *identify data that can be used to characterise drivers of rural disaster resilience.* A review of the New Zealand data landscape is undertaken at this stage to understand data availability, accessibility and usability, and key barriers to the use of data for DRR. A review of available data in New Zealand informs the collection of indicator datasets of changing rural disaster resilience.

1.4.2.3 Indicator Development

The indicator stage builds upon the literature and data review to identify measurable indicator datasets for quantifying change in rural New Zealand.

1.4.2.4 Data Visualization

Stage four is the visualisation of indicators datasets, using primarily geospatial analysis.

1.4.2.5 Evaluating Impacts on Rural Resilience

Stage five addresses objective 3; *evaluate the impact of a dynamic changing environment on rural disaster resilience*. The impacts are discussed through the lens of the Living Standards Framework and its four capitals; human, social, natural and financial/physical. The Living Standards Framework is presented in Figure 1.2.

1.4.2.6 Methodological Limitations

This section outlines limitations presented by the research methodology. Due to the synthesised nature and scope of the research, quantifying the impacts of rural change on disaster resilience would ideally be investigated more thoroughly. Kay et al. (2019) note some community resilience tools can only capture some community complexity, and should therefore be supplemented with a 'bottom up' approach - with local level

data. Wynne (1992) recognises this tension and suggests that top-down approaches can *"exaggerate the scope and power of science knowledge"* and that this leaves a gap where discourse about the social context and boundaries of this knowledge exist (Barclay et al., 2008). Further research to establish more clearly the community level impacts of change presented in this thesis, will better allow the identification of rural disaster resilience drivers. Disaster resilience is highly contextual, the use of the Living Standards Framework to begin to evaluate the impacts of rural change represent a basic attempt at quantifying the potential impacts of change. The research process presents a base from which to begin rural resilience investigation, and understand the drivers of past, present and future disaster risk, rather than an all-encompassing summary of disaster resilience drivers.

The nature of research data in New Zealand, means that many drivers of rural disaster resilience were unable to be included in the results. Data were excluded for reasons including a lack of geographical and temporal spread. This lack of data means that this research does not represent the true breadth of those who live and work in rural New Zealand, such as non-agricultural rural community members (such as tourism workers and lifestyle block owners). Where appropriate, this has been outlined throughout the research.

1.5 The Rural Disaster Resilience Field

The National Disaster Resilience Strategy (2019) highlights the need to develop methods for showing the impacts of decision making on resilience (Basher, 2016; Kay et al., 2019). It notes that risk management is challenged by the complexity of the systems that impact on the LSF wellbeing capitals. The LSF links wellbeing to things like income, education, community engagement and housing. The NDRS notes that it is imperative that resilience and risk management play a part in all four wellbeing capitals (MCDEM, 2019). Therefore decision makers require more comprehensive strategies that not only include risk management, but the enhancement of societal resilience with the use of tools such as the Living Standards Framework (MCDEM, 2019).

This research is intended to add to and build upon a wealth of rural data and research in New Zealand, and explore avenues of understanding rural disaster resilience drivers. This also provides the basis for beginning to understand how future resilience changes may impact rural communities. A cohesive summary that investigates the drivers and outcomes of rural disaster risk and resilience over multiple dimensions in the rural sector, could form a powerful decision-support tool for rural communities, researchers and disaster decision-makers (Spector et al., 2017).

1.6 Theoretical Framework

This thesis utilises a synthesis approach, in which many different strands of knowledge are used to build a picture of rural resilience (outlined in Figure 1.3). Berkes and Ross (2012) identify the need for a more integrated, synthesised approach to community resilience. As community resilience sits within a complex environment, drawing from many different disciplinary avenues contributes to a more comprehensive approach to resilience, informing new research directions and DRR practice (Berkes & Ross, 2012). Brown and Westaway (2011) argue that the process of synthesising knowledge from different sources to co-produce new knowledge is a key step in comprehensive research analysis.

Spector et al. (2019) notes that a research synthesis approach using both quantitative and qualitative methods are better suited to interdisciplinary research, particularly when the research aim is to understand how and why policy/practice works, and for whom (Berrang-Ford, Pearce & Ford, 2015). This approach is particularly useful when faced with the challenge of integrating multiple data sources and formats, and fosters an inductive research process. Berrang-Ford et al. (2015) note that for climate change research, synthesis methods are required to document where adaptation is taking place and evaluate whether it is translating into action. The authors note that this is also important for informing governance systems of the current status and gaps in climate change adaptation (Berrang-Ford et al. 2015). Therefore the application of

this approach to an analysis of dynamic temporal rural disaster resilience drivers is fitting.

As a methodological approach, the synthesis of available rural resilience indicator data is intended to reveal existing understanding of, inconsistencies and gaps in the current body of research (Spector et al., 2019; Haddaway & Pullin, 2014). Synthesis of data strengthens the value of each individual strand of knowledge and improves understanding of the links between different disciplinary contexts (Brown & Westaway, 2011). This approach is informed by a range of sources including the NDRS, the Sendai Framework and international disaster resilience literature, exploring indicator use across different contexts (Cutter et al., 2010; Stevenson et al., 2017).

2 LITERATURE REVIEW

2.1 Introduction

This literature review addresses objective 1; *identify temporal drivers of changing disaster rural resilience*. Firstly through a review of global research with a focus on identifying broad trends of changing rural disaster resilience. This is followed by a review of New Zealand rural disaster resilience literature. This is stage one of the methodology (Figure 2.1). This literature review contextually grounds the research in a way that ensures any outputs will be useful, usable, used, and highlights potential priority areas of focus, informing the rest of the methodology and framing the rest of the research.

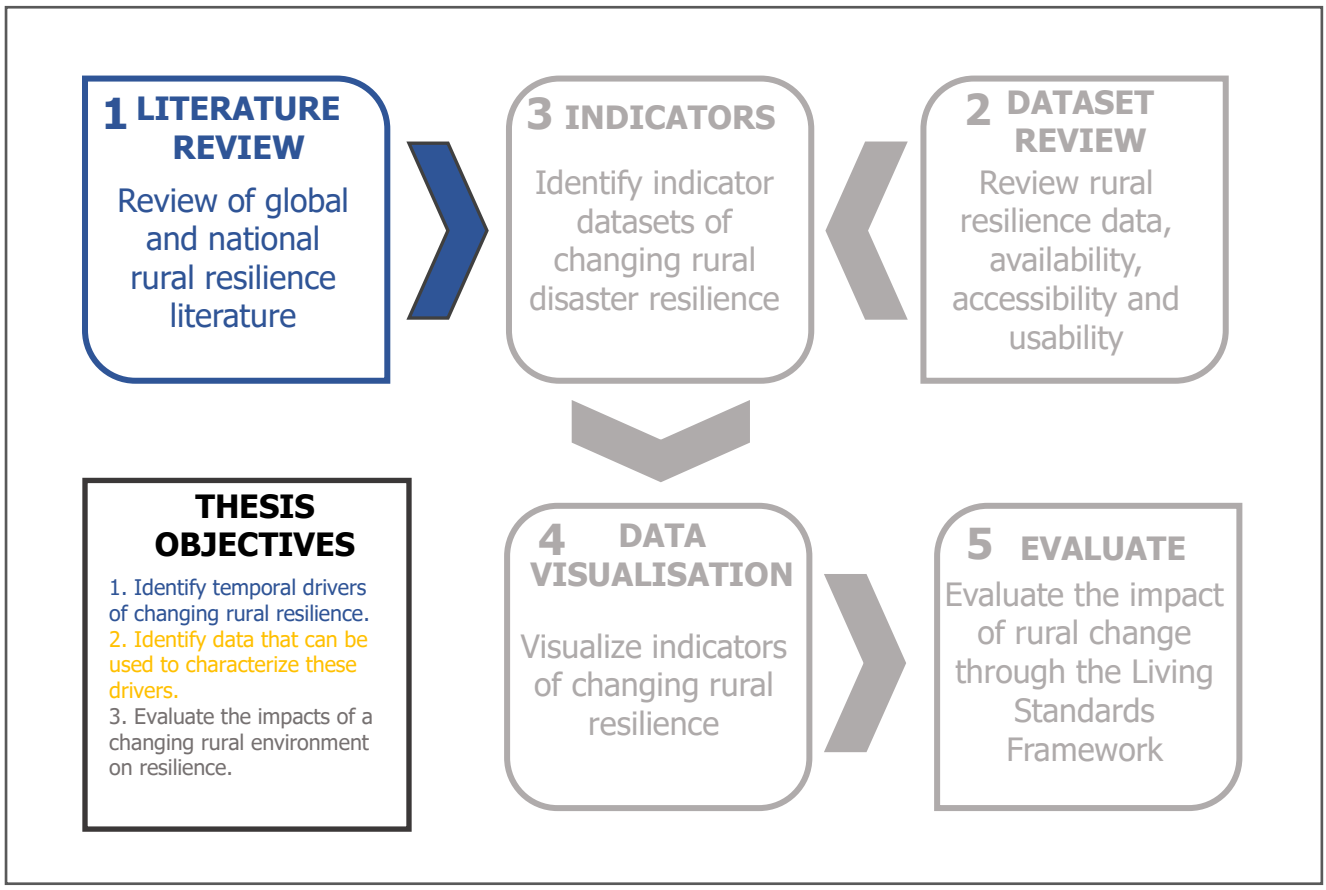


Figure 2.1 Literature Review Stage of the Methodology

2.2 Rural Disaster Resilience

Whilst a broad base of research has emerged over the past few decades in urban resilience and disaster risk (Flint & Luloff, 2006; Pelling, 2003; Leichenko, 2011), rural disaster research is less prominent in the literature (Cutter et al., 2016). A large proportion of global rural resilience research is focused on rural disaster risk in developing countries. In the Sendai Framework, priority areas of focus emphasise managing the resilience of marginal rural settings, such as those of developing countries through land use planning and management (Pica, 2018; Sendai Framework, 2015; Prevention Web, 2015).

Research focused on rural areas in more developed countries, and the specific characteristics that influence disaster risk and resilience, is less extensively covered in the literature (Cutter et al., 2016). It is critical to address the needs and vulnerabilities of rural community resilience, as these areas present different challenges than urban areas for disaster management practitioners, policy makers, and community members themselves (Kapacu, Hawkins & Rivera, 2013). Additionally, the disaster resilience of rural communities is often overlooked in favour of larger urban societies (Smith et al., 2011).

The term resilience is used in an abundance of different research fields and contexts, however at its core it refers to the capability of an entity to return to stability after disruption (Bhamra, Dani & Burnard, 2011; Holling, 1973; Paton & Johnston, 2001; Zhou et al., 2010). Weichselgartner and Kelman (2014) describe resilience as a flexible concept, residing in the interface between science, policy, and practice as both an action, and also as a unifying vision. They note that in DRR, transitioning resilience from concept to action can be challenging due to this multitude of meanings. While this reflects the interdisciplinary nature of resilience research, it also means that it is important to use a critical lens to define 'resilience' within the research context (Bhamra et al., 2011; Davoudi, 2012; Stumpp, 2013; Wilson, 2013; Gallopin, 2006; Klein, Nichols & Thomalla, 2003; Spector et al., 2018; Fielke et al., 2018).

Bhamra et al. (2011) identify three broad areas of disaster risk and resilience literature; preparedness and readiness, response and adaptation, and recovery or adjustment. Within this, researchers utilise multiple terms and conceptual approaches, some of which have interchangeable meanings, to refer to rural disaster risk and resilience. Some of these include; vulnerability, capacity, adaptive capacity, socioecological systems, organisational resilience, sustainability and community resilience (Scott et al., 2000; Bhamra et al., 2011; Weichselgartner & Kelman, 2014; Davoudi, 2012; Spector et al., 2018; Cutter et al., 2016; Mavhura, 2017; Tanner et al., 2015; Smith et al., 2011).

Whilst this provides a broad range of perspectives on rural community resilience and risk, this research will use a DRR approach to resilience, defined as; *"the ability of a system, community, or society exposed to hazards to resists, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner"* (UNISDR, 2009).

In addition to the complications that arise when defining resilience, 'rural' is a similarly contested term (Madsen & O'Mullan, 2016). Rural spaces are multi-dimensional and dynamic, and are embedded within a wider context of governance, policy, economy, culture and social norms (Ilbery, 1998; Halfacree, 1993). What is meant by the term 'rural' and the surrounding discourse is highly contextual, rural spaces are not just a collection of farms but are intricately connected with cultural meaning, conceptions of lifestyle, geographical location and livelihoods (Cloke, 2006; Cloke & Milbourne, 1992; Halfacree, 1993; Halfacree, 2004; Ilbery, 1998; Pratt, 1996).

In light of these contested terms, in the literature many characteristics are considered components of rural disaster resilience, some of which overlap and have multiple meanings. These include; values and differences in risk perception, economic and physical risk, stakeholder risk and preparedness, coping strategies, social capital, local knowledge and adaptability, and relationships between governing bodies and communities (Darnhofer et al., 2010; Miller et al., 1999; Paton & Johnston, 2001; Sampson & Goodrich, 2005; Jakes & Langer, 2012; Rouse et al., 2017; Glavcovic et

al., 2010; Spector et al., 2018). Other broad themes address adaptive capacity, community linkages, economic and physical capacity, social capacity, communication and culture and heritage (Kapacu et al., 2014; Brody, Kang & Bernhardt, 2010; Norris et al., 2008; Pica, 2018). Additional areas of focus include organisational resilience, diversification and intensification, and managing supply chain risks (Spector et al., 2018; Kachali et al., 2012; Pomeroy, 2015; Spector et al., 2018; Basset-Mens et al., 2009).

This demonstrates the range of research perspectives that inform the rural disaster resilience field (Madsen & O'Mullan, 2016; Zhou et al., 2010). The scope of this research field, necessitates that any research be well defined, not only to guide the research but to identify where potential gaps may exist. While many different characteristics and features of resilient communities have been identified, Madsen and O'Mullan (2016) emphasise that a deductive, singular approach to these characteristics could limit understanding of community resilience as a whole, dynamic system, subject to change. Spector et al. (2018) suggest the need to consider rural resilience from multiple perspectives, in particular the need for further exploratory research using methods such as the examination of historical materials to analyse how the disaster resilience of rural communities has changed over time.

2.3 Approaches to Rural Disaster Resilience

Research approaches to rural DRR are changing from a historically technocratic 'for the community' approach, to a 'with the community' approach (Pearce, 2003; Fielke et al., 2017). Pearce (2003) states that in Australia, disaster management is shifting from a response and recovery focus to a mitigation centric approach, a shift that requires more contextual community input. This is because whilst a top-down, policy approach can be required, it is the bottom-up actions that drive implementation and successful DRR (Pearce, 2003). This shift in approach is key, as it shifts DRR from a purely hazard focus to one that incorporates vulnerability and exposure as well as community and multidisciplinary interests. Despite this shift, Flint and Luloff (2006) state that some disaster research perspectives emphasise environmental and social vulnerability over community level experience, therefore, much rural based disaster

research is incomplete. This can be linked to a sometimes overly static understanding of community risk and resilience which can lack an understanding of community structure, socioeconomic forces, demographics, and community identity as influences on disaster risk and resilience (Bender, 1978; Boon, 2014; Madsen & O'Mullan, 2016; Murphy, 2007). Cox and Perry (2011) identify that in the context of disaster risk, a consideration of the complexity of communities will result in a more nuanced approach to resilience.

While the term resilience is a contested one, with no singular agreed definition, the concept of resilience is the foundation of many public policies and programmes (Beccari, 2016; Ivory & Stevenson, 2019). However there is little consensus on robust resilience assessment and application (Parsons et al., 2016; Ivory & Stevenson, 2019). Ivory and Stevenson (2019) state that measurement is at the 'coalface' of the resilience process, with robust benchmarking and monitoring vital when managing or planning for resilience. This is further supported by Sharifi (2016) who states that the measurement of community resilience is not only an essential step in DRR, but also provides a window in the different *"environmental, social, economic physical and institutional elements of a community related to resilience" (p.630)*. Therefore, investigating drivers of rural disaster resilience is one way of operationalising a commonly intangible concept (Kay et al., 2019; Martin-Breen & Andries, 2011). Transforming disaster resilience into a measurable element encourages planning for future uncertainty and also allows complex communities to be better understood. Sharifi (2016) defines this as a connection between theoretical and tangible.

DRR has a wide range of methodologies, tools, and indices for the assessment of resilience. These help identify areas of vulnerability, and also highlight potential points of intervention (Frankenberger et al., 2013). Additionally, methodologies and tools can be used post DRR activity to monitor efficiency and effectiveness of DRR implementation (Khazai et al., 2015). Sharifi (2016) notes that some, such as community resilience assessments can be particularly useful for determining changes in communities over time, such as longitudinal assessments of vulnerability to hazards.

Many different measures, or drivers of changing resilience do not fit neatly into a single definition and in fact can change dependent on context. However, utilising a synthesis framework to bring together many different sources of knowledge allows the development of a robust methodological approach. Synthesis frameworks help to structure research that is often a blend of qualitative and quantitative, in a way that allows for theoretical application (Miles, 2015). Using a disaster resilience based framework that can be both qualitative and quantitative also fosters interdisciplinary participation, potentially improving implementation of DRR in communities.

2.4 Drivers of Rural Resilience

Rural communities occupy a unique space between urban society and the natural environment, subject to the influences of external forces and environmental change (Flint & Luloff, 2006). This juxtaposition and the complex social, cultural and political forces which shape them means that analysis of resilience and disaster risk must take this complexity into account. Ilbery (1998) emphasises that the rural environment is dynamic, with change that can be multidimensional, and in response to a range of social, economic, political and environmental factors. Complexities in rural community research are well documented and indicate a need for strengthening understanding of resilience in a rural context (Cutter et al., 2016; Flint & Luloff, 2006; Chalmers & Joseph, 1998; Ashkenazy et al., 2018; McManus et al., 2012). Rural communities are diverse, potentially including tourists, farmers, lifestyle block residents, tourism operators and migrant workers, all of whom can have different levels of resilience and vulnerability (Spector et al., 2018). At an even broader scale, rural areas may have multiple communities with different levels of resilience, experiencing different levels of change. For example, while some rural areas close to urban areas may experience increasing populations, some rural areas, far from urban centres, may be experiencing population decline (Elms, 2015; McManus et al., 2012).

These factors mean that rural regions often face compounding impacts of social, cultural and economic change alongside the impact of hazards (Burton & Peoples, 2014; Pomeroy, 2015; Amundsen, 2012). A changing rural environment impacts rural

disaster resilience, however the varied, and subtle nature of this change means that it can be difficult to discern high level factors that may influence community disaster resilience. Additionally, rural resilience is often characterised in regard to risk to a typical 'agricultural' community, therefore, rural vulnerabilities in the literature prominently appear to be related to social and environmental change and intricately connected to livelihood resilience (Race et al., 2010; Lockie, 2000; McManus et al., 2012; Liu et al., 2007; Gwimbi, 2009). This also makes comparative rural research challenging as research is context specific and can be hard to generalise (Howie, 2008).

Therefore there is a need to establish common drivers of changing disaster resilience in rural communities. The New Zealand Department of Prime Minister and Cabinet (DPMC) has identified four categories of long term trends that influence risk and resilience; societal, technological, economic and environmental (Frieling & Warren, 2018). Indicators of changing rural disaster resilience can be grouped under these trends.

2.4.1 Societal Trends

In the literature, population shifts, and subsequent demographic change are identified as drivers of changing rural disaster resilience. A study of the implications of demographic change on Australian rural communities, found that population movement was a complex challenge to resilience, particularly in maintaining a viable social fabric and networks (Race et al., 2010). McManus & Pritchard (2000) identify the last 50 years as a time of huge demographic and livelihood change in rural and regional Australia and that maintaining social networks and social fabric are a key part of community disaster resilience (Cox & Hamlen, 2015). Amundsen (2012) notes that change at different temporal and spatial scales affected the resilience of a small Norwegian rural community. Population migration toward urban centres and a low birth rate drove population decline. Set against the backdrop of changing economic opportunities, Amundsen noted that this challenge to social networks had impacted community resilience (2012).

Changes to the rural environment, particularly through the closure of physical places like a bank or post office have been associated with changes to community disaster resilience. Rural service provision is often interchangeably identified as the 'rural way' of life, with services as the glue that holds the community together (Woods, 2006). Conversely, the closure or reduction of rural services is often seen as a threat to the 'rural way' of life. In many ways rural services have not only functional properties but strong symbolic meanings as core components of the rural community. Rurality is often defined by the presence of these services, and so the loss of services like the bar, post office or local store are often seen as the loss of community.

Service providers such as banks, schools and post offices in rural communities serve more than just their primary function; Kearns (1991) notes them as important markers of community memory, identity and function, often serving as ad hoc community centres, making important contributions to social networks and community life (Coster, 1999; Witten et al., 2003). Joseph (2002) notes, that "*service provision is the critical link between rural settlements and rural people; services support people and people support services*". McGranahan & Beale (2002) identify access to essential services as a major challenge in the rural United States, as health, education and retail services have consolidated into larger units over time, with less physical presence in rural areas. This has been closely associated with changing employment opportunities, demographic fluctuation and economy. Amundsen (2012) noted that resources and services are "*the foundation of community resilience*" and in the context of small communities, institutions such as schools, medical centres and post offices function as aspects of social fabric, fostering human and social capital. Scott et al. (2000) note that the loss of basic services in rural areas is said to "*undermine the sustainability of rural communities*". However they also note that service changes have a range of implications for different groups of people with the stratification of socio economic status in rural communities meaning the impacts of these changes are unequally felt.

2.4.2 Economic Trends

An important factor in changing disaster resilience is economic trends. A case study from the 2011 Brisbane Flood, indicated that several factors contributed to poorer outcomes post disaster, including the location of vulnerable populations and pre disaster economic stability (Wickes et al., 2015). These links between pre disaster context and post disaster recovery highlight the need for better understanding of community drivers of change (Rahmawati, Rachmawati & Prayitno, 2018).

In a comparison of eruption impacts of the 1945 and 1995-1996 Ruapehu eruptions, Johnston et al. (2000) found that between the two eruptions, social and economic change were the main drivers of greater impacts in the later eruption. Whilst both eruptions were similar, considerably greater impacts in the second event were felt due to the temporal change experienced by communities in the area. These included population change, economic diversification and infrastructure change (Johnston et al., 2000). Sundet and Mermelstein (1997) note that for Midwestern US rural communities, impacted by a devastating flood, post disaster consequences were not just the result of an isolated and overwhelming hazard, but the rest of a "decade-long, cumulative, economic, and social challenge to durability". Drivers of this change included rural economic restructuring and changing community demographics (Donner & Rodriguez, 2008). Pomeroy and Newell (2011) emphasise that a strong and diversified economic base is one characteristic of a resilient community.

2.4.3 Environmental Trends

Environmental trends have been identified as a driver of changing rural disaster resilience. This can include factors like changing climate and hazards, as well as factors like land use change. Pomeroy and Newell (2011) notes that rural communities in New Zealand face challenges to resilience including changing climate, and more intensive meteorological events, and that adaptation to this is a priority for these communities. The National Disaster Resilience Strategy (2019) identifies climate change and environmental trends as a key challenge to future resilience. This includes changing trends in things like the use of natural resources, land use, climate resilience, and

understanding of natural hazards. McManus et al. (2012), note that the environmental aspects of rural disaster resilience can be poorly understood. Wilson (2010) notes that rural places with well-developed environmental, social and economic capital are likely to be more resilient. Panelli, Stollte and Bedford (2003) note that agricultural change is a recurring theme in rural studies throughout the world, in particular, changing land use in response to socioeconomic change. They note a similar thread in many rural communities around the world, shaped by trends including the increased scale of faming, industrialisation, the rationalisation of state and service functions and changing population demographics (Panelli et al. 2003). This is reflected in the changing activities taking place in rural communities such as the move from agriculturally dominated activities to tourism and lifestyle block migration. This is important for DRR because the vulnerabilities of different farming types and communities vary over space and time, so the impacts of change can be disproportionate. Smith et al. (2012) suggests that there is not a simple relationship between resilience and farming, but that this is influenced by the nature and structure of the farm business itself. Some land use changes have been associated with worsening community resilience. Pomeroy and Newell (2011) note that in some New Zealand communities, the conversion of land to forestry has been associated with the loss of services (like local schools), and an *"erosion of community"* (Pg.3).

Another environmental trend is the impact of natural hazards and climate variability. One example of this is drought; although drought is linked to meteorological conditions, the impacts of drought are modified by environmental factors, irrigation, and broader social and economic conditions (Botterill, 2003; Smith, Kelly and Owen, 2012). The implications of drought on agriculture have been well documented, and Smith et al. (2012) argue that the reality of repeated droughts needs to be normalised in policy and community decision making, in part, to address the social impacts of drought on rural businesses, families and communities, and the subsequent impacts of this on disaster resilience.

2.4.4 Technological Trends

Technological change can also contribute to changing disaster resilience. Frieling and Warren (2018) identify several drivers of technological change. In New Zealand, investment in irrigation technology and infrastructure has allowed farm intensification and conversion to higher value land uses like dairying. Other technological change includes changes in broadband and telecommunications availability for rural areas. Access to broadband means that services like banking no longer need to have a physical presence in the community. However the equality of access to technology could also have an impact on resilience in communities. Community broadband initiatives have been linked to rural resilience (Heesen, Farrington and Skerratt, 2013; Roberts et al., 2017). Heesen et al. (2013) found that for two rural communities in the United Kingdom, rural broadband initiatives improved social connectivity and the ability for community members to access resources.

Future technological trends are also an important consideration for rural resilience, innovation in agricultural practice could improve agricultural outputs. Viviano (2017) notes that the Netherlands, a small country, has become a major global exporter of food as agricultural technologies have reduced crop dependence on water and improved agricultural outputs. Research and development efforts for climate change mitigation and adaptation technologies may also affect future rural resilience (Frieling & Warren, 2018).

2.5 Rural Resilience in New Zealand

The application of disaster resilience research to rural communities is relatively new in New Zealand, with only one article published before 2001 (Spector et al., 2018). However, in line with international resilience research, there appears to be an increasing trend of studies on factors that drive rural disaster resilience and change. There is not yet a cohesive summary that investigates the drivers and outcomes of rural NZ change over multiple dimensions in the rural sector (Spector et al., 2018). However, research has begun to understand what factors can increase and decrease disaster resilience within rural communities. This research indicates that community response following disasters is dependent on pre disaster context (Whitman et al.,

2013; Wickes et al., 2015). Links between pre disaster context and post disaster recovery highlight the need for better understanding of community drivers of resilience and communication of this information to policy makers, community members and disaster decision makers (Wickes et al., 2015).

2.5.1 A History of Rural New Zealand

This section provides a brief overview of the evolution of New Zealand rural communities. The purpose of this is to provide a deeper understanding of the forces that have shaped rural communities and how this has contributed to the present day context.

At the outset it must be acknowledged that community structure, conceptions of place and identity in New Zealand can be somewhat bi-culturally contested. Legacies of colonialism, immigration and the signing of the te Tiriti o Waitangi/the Treaty of Waitangi, mean that exploring attributes of New Zealand rurality must acknowledge these shared, and different realities (Kearns & Joseph, 1997). The loss of Māori owned land and other resources was largely gained by Pakeha, and much of New Zealand's subsequent agricultural and economic development relied on this exploitation. Whilst the development of 'rural New Zealand' drove nation building, economic growth, and moulded demographic composition and social dynamics, the extent to which it continues to define communities today should be acknowledged. As noted by Hayward (2013), the lens of 'resilience' can sometimes focus on disruption as external to a community, or system. However interactions between gender, class, and ethnic inequality exacerbate vulnerability for different groups. Additionally, different types of resilience analysis could obscure the privileged trajectory of economy and power across time and space (Hayward, 2013). To delve further into this is beyond the scope of this research but has been further covered by academics (Bell, 2009; Hayward, 2013; Kearns & Joseph, 1997; Law, 1997; Pool, 2017).

Modification of land for agricultural purposes began between 500 and 750 years ago, when a growing Polynesian population used fire to clear land for agriculture (McGlone,

1989; MacLeod & Moller, 2006). More dramatic modification of the land began upon the arrival of European settlers in the early 19th century (MacLeod & Moller, 2006). Early European settlement was driven by pastoralist ideals and largely recreated British landscapes, settlers cleared bush and planted introduced grasses and crops. The construction of a comprehensive road and railway network from 1870 onwards helped forge linkages between numerous rural settlements and urban towns. Over 2000km of railway lines were built by 1880, opening up regions to Pakeha settlement and almost doubling the population of the colony in just ten years, with 60% of the population living in rural areas (Fraser, 2006).

The trade of New Zealand's natural resources laid the foundation of an export focused economy that began with whales and seals, followed by gold, and wool, and finally meat and dairy (Fraser, 2006). The first successful shipment of frozen meat to England in 1882 cemented the nation's place as the 'farmyard' of Britain, enabling the growth of the economy based on agriculture (Fraser, 2006). Agriculture in New Zealand is intricately linked with economy, culture and politics (Liepins & Bradshaw, 1999). For many years, rural community rhetoric was dominated by the 'family farm' idyll, with community life centred on a church, school and pub (Smith et al., 2011). Many rural communities were buoyed by agriculture and the services associated with it, such as freezing works, often a major employer in small towns, as well as retail, banking and postal services (Press & Newell, 1994).

2.5.2 Drivers of Rural New Zealand Change

These communities have faced fluctuating change; from the 1950s and 1960s when the strength of the rural economy meant the New Zealand standard of living was one of the highest in the world, to the 1970s and 1980s when a decline in export demand and an end to agricultural price supports drove rapid social change (Fraser, 2006; Pool, 2017; Smith & Montgomery, 2004; Smith, 2006). The catalyst for this change was primarily a series of policy changes in the 1980s; most notably, the removal of farm subsidies and the withdrawal of state intervention in much of the services sector (Fraser, 2006; Howard, 2015; Joseph et al, 2001; McMillan, 2015; Payne et al, 2019; Rutledge et al., 2008; Smith & Montgomery, 2004; Smith, 2011; Spoonley, 2016).

These changes greatly impacted rural communities. Many farmers were abruptly exposed to the global market, and lost agricultural financial support; approximately 40% of sheep and beef farm income came from the government in 1983 (Smith & Montgomery, 2004). The impacts of this on other rural services was also substantial. Walker and Bell (1994) estimate that for every dollar not spent by impacted farmers, three dollars was not spent on rural and agricultural services such as meat processing plants, many of which closed as livestock numbers fell, sometimes the loss of a major employer for small rural towns (Press & Newell, 1994). Alongside this, the withdrawal and privatisation of much of the services sector, meant that many rural communities underwent a contraction in public services, left unfilled by the private sector while simultaneously experiencing sudden economic downturn (Joseph et al. 2001).

The State Owned Enterprises Act of 1986 heralded major change in New Zealand's state sector, a number of government departments became more commercially oriented, with a push for greater efficiency and profitability (Goldfinch, 1998). Many small communities, especially rural ones, bore the brunt of this rationalisation in services. The transfer of many services to the private sector meant that those that were inefficient or uneconomic were shut down or dramatically reduced (Woods, 2006). Additionally, the principle of 'standard pricing' for rural services also gradually eroded, with pricing now reflecting geographical variations in cost. These changes can more dramatically impact rural areas where smaller populations that are sparsely populated become disadvantaged. As a result, a number of rural towns were left with a lack of service representation. Additionally, technological change such as access to broadband and telecommunications has changed the nature of services in many rural towns and in many places, lessened the physical presence of these services.

The rapid and visible nature of this change is often pointed to as the catalyst for New Zealand's 'dying' small towns. While it no doubt had a significant impact on many rural communities, many pre-existing trends in rural communities were already well established, including rural depopulation and community service decline (Bedford & Heenan, 1987; Joseph et al., 2001). Subsequent population trends including the

movement of 'life-stylers' back to rural areas has also continued to alter these communities. As well as ongoing changes in land use practice, such as the growth of rural tourism and dairy and horticulture conversion. Smith et al. (2011) suggests that spatial patterns of rural activity have shifted, with a subsequent impact on rural perceptions of community and resilience (Fairweather & Mulet-Marquis, 2009).

In the literature, 'rural decline' is often subsumed into agricultural change (Scott et al., 2000). While agricultural change no doubt plays a significant role in changing rural communities, it should be noted that rural change impacts different groups in varied ways, and social factors, such as marginalisation can exacerbate these impacts. Rural social change can also happen independently of agricultural factors (Bedford et al., 1999; Pomeroy & Newell, 2011).

Having a clear picture of the drivers of change in rural communities is important, as disaster risk reduction can be highly contextual – for example, variabilities in population demographics can make it hard to discern vulnerability for some rural areas (Cutter et al. 2016; Elliott & Pais, 2010; Tobin & Whiteford, 2002). Fielke et al. (2017) state that understanding the implications of change in rural communities has driven resilience thinking into mainstream transdisciplinary research. Despite this kind of research, there is still some way to go in the development of a suite of common rural community disaster resilience drivers, and in fact, understanding and applying measures of rural community resilience illustrates the array of differences across these landscapes (Cutter et al., 2016).

2.6 The Living Standards Framework

This section presents the Treasury Living Standards Framework (LSF). The framework is used to analyse the impacts of policy on intergenerational wellbeing and is framed by four capitals:

1. Natural
2. Human
3. Financial & Physical

4. Social

The impacts of rural change are evaluated using the four capitals of the Living Standards Framework, presented in Figure 2.2. The framework helps to inform government priorities, policy decisions, and investment (New Zealand Treasury, 2018). The goal of the LSF is to enhance natural, social, human and financial/physical capital to improve the wellbeing of communities (Frieling & Warren, 2018). As a part of New Zealand's DRR governance environment, the LSF capitals have been used to assess the potential impacts of policy and change, the wellbeing vision also underpins the National Disaster Resilience Strategy (MCDEM, 2019).

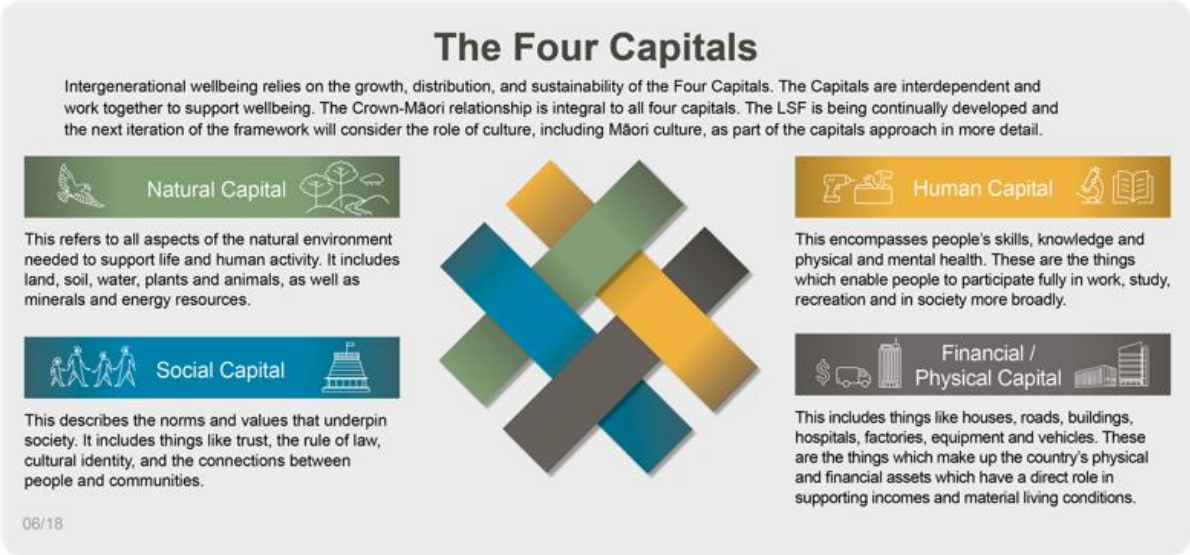


Figure 2.2 The Four Capitals of the Living Standards Framework (New Zealand Treasury, 2018)

Frieling and Warren (2018) state that there is an opportunity to improve the management of risk through the use of the LSF, as the four capitals encourage a more systematic consideration of risk and resilience. They note that traditional risk management can be restricted to certain capital perspectives, such as financial, rather than also including the human and social viewpoints (2018). Zander, Hatvani-Kovacs and Garnett (2017) note that conceptualising community resilience as a set of capital assets, allows for integrated risk management at both individual and institutional governance scales. The capitals as an indicator of community disaster resilience should not be considered in isolation, and all influence each other, thus any considerations of

changing resilience should allow for this. Specific capital definitions and how they relate to resilience and rural change are presented in the following sections.

2.6.1 Social Capital

The LSF defines social capital as *"norms, rules and institutions that influence the way in which people live and work together and experience a sense of belonging. Includes trust, reciprocity, the rule of law, cultural and community identity, traditions and customs, common values and interests"* (New Zealand Treasury, 2019). From a DRR perspective, social capital can be defined as the resources that people draw from their connections to others that aid in community action (Aldrich, 2017). Social capital is commonly equated directly with community resilience, as high levels of social capital tend to result in trust, information sharing and often, increased participation in DRR activities (Bankoff, 2015; Coleman, 1988). Strong social capital is essential for communities living with risk and an important factor in DRR (Adger, 2003; Aldrich, 2017).

The range of factors that influence social capital is highly complex, and contextual. Many researchers note demographic change, population change, and economic change can have a substantial impact on rural social capital. Demographic characteristics in rural communities have been documented as playing a significant role in the development of social capital (Cutter et al. 2016; Vallance & Carlton, 2015; Fraser, 2006; Statistics NZ, 2017). Studies in New Zealand and the USA found that rural farming and non-farming organisations were sensitive to changes in social capital and had a high dependence on social, informal and family networks following disasters (Whitman et al, 2013; Besser et al. 2008). Social and economic policy reforms experienced by rural communities in New Zealand are often seen as a causative factor in the loss of social capital (Ashton & Thorns, 2007; Pomeroy & Newell, 2011). Bedford et al. (1997) identified that major structural change over the previous 15 years in New Zealand had resulted in a "run-down of social capital" (Bedford et al. 1999, pg.87; Pomeroy & Newell, 2011).

2.6.2 Human Capital

The LSF defines human capital as "*individuals' skills, knowledge, mental and physical health that enable them to participate fully in work, study, recreation and society, including skills, knowledge and physical and mental health"* (New Zealand Treasury, 2019). Human capital is a largely non-material concept, but is influenced by a range of factors. Hayward (2013) notes that the concept of resilience, and the language it uses, can often fail to reflect the non-material, intangible aspects of community (Adger et al., 2011). Additionally, Hayward (2013) notes that the lens of 'resilience thinking' can sometimes focus on disruption as external to a community, or system. However, interactions between gender, class and ethnic inequality exacerbate vulnerability, and influence human capital and resilience.

The nature of the term 'community' introduces more challenges to DRR based research and human capital (Sharifi, 2016). Smith et al. (2011) note that in rural New Zealand, the term 'community' does not have a homogenous meaning, and is not tied to a delineated place or territory. Instead 'community' can be seen as a social construct, continually made through daily experience and practice, commonly at certain locations such as the local school (Agrawal & Gibson, 2001). Norris et al. (2008) identify that building community disaster resilience, involves a process of building a network of adaptive capacities, such as the capacity to develop capital through social belonging, a sense of community and participation. Brown and Kulig (1996, p. 43) note that, *"people in communities are resilient together, not merely in similar ways".* Possibly due to small size and geographic locale, rural communities tend to foster a sense of belonging and identity (Cox & Hamlen, 2015). While aspects of human capital are intangible, rural communities have undergone physical changes that could indicate changing human capital, such as the loss of community services, like schools and medical centres.

2.6.3 Natural Capital

The Living Standards Framework defines natural capital as *"all aspects of the natural environment that support life and human activity, including land, soil, water, plants*

and animals, minerals and energy resources" (New Zealand Treasury 2019). Factors that could influence natural capital include broader ecosystems as well as the interactions between environmental assets, such as the impact of agricultural intensification on soil quality. Natural capital is important for hazard protection (e.g. storm and erosion protection) and also food and financial security (Frieling & Warren, 2018). Kousky (2010) notes that actions to build natural capital can lower hazard risk and impacts, such as through stabilising slopes with vegetation to prevent landslides.

Natural capital is intricately tied to rural livelihoods, with the driving forces of land use, agricultural practice and land ownership tied to political, social, and economic factors. Indicators of changing natural capital could include phenomenon like drought or hazard impacts and changing agricultural practices. Natural capital quantifies the context in which rural community resilience changes. Zander et al. 2017 state that natural capital underpins all assets and that, without natural capital, no other capital stocks can be built and maintained (Fischer et al., 2007). Zander et al. (2017) note that there is a need for better adaptation to improve resilience to climate change as driver of natural capital.

2.6.4 Financial & Physical Capital

Financial and physical capital is defined as the "*financial and human-made physical assets, usually closely associated with support material living conditions. Includes factories, equipment, houses, roads, buildings, hospitals and financial security"* (New Zealand Treasury, 2019). In New Zealand, changing financial capital for farmers in rural communities in the 1980s had flow on impacts for rural services (Walker & Bell, 1994). McManus et al. (2012) note that rural communities in Europe and North America have suffered long term economic and social pressures challenging their vulnerability to external change (Norris-Baker, 1999). Zander et al. (2017) note that strong financial capital is vital, as those with financial capital can invest in resilience activities. Changing physical capital can result from the maintenance and renewal of infrastructure networks and buildings, natural hazard and extreme weather impacts, and economic change. Zander et al. (2017), note that technology and infrastructure can boost physical capital and improve resilience. They note that government

investment in infrastructure, such as transport, can increase economic productivity thereby also improving financial capital.

3 DATA IN NEW ZEALAND

3.1 Introduction

This chapter addresses objective 2; identify data that can be used to characterise drivers of changing rural resilience. A review of the New Zealand data landscape was undertaken at this stage to locate available datasets and understand key barriers to the use of data for DRR. This informs a suite of measurable indicator datasets of rural change. This is stage two of the research methodology; undertake a data review, to identify data that can be used to characterise drivers of change**.** Followed by stage three of the methodology; identify indicator datasets of changing rural disaster resilience (Figure 3.1).

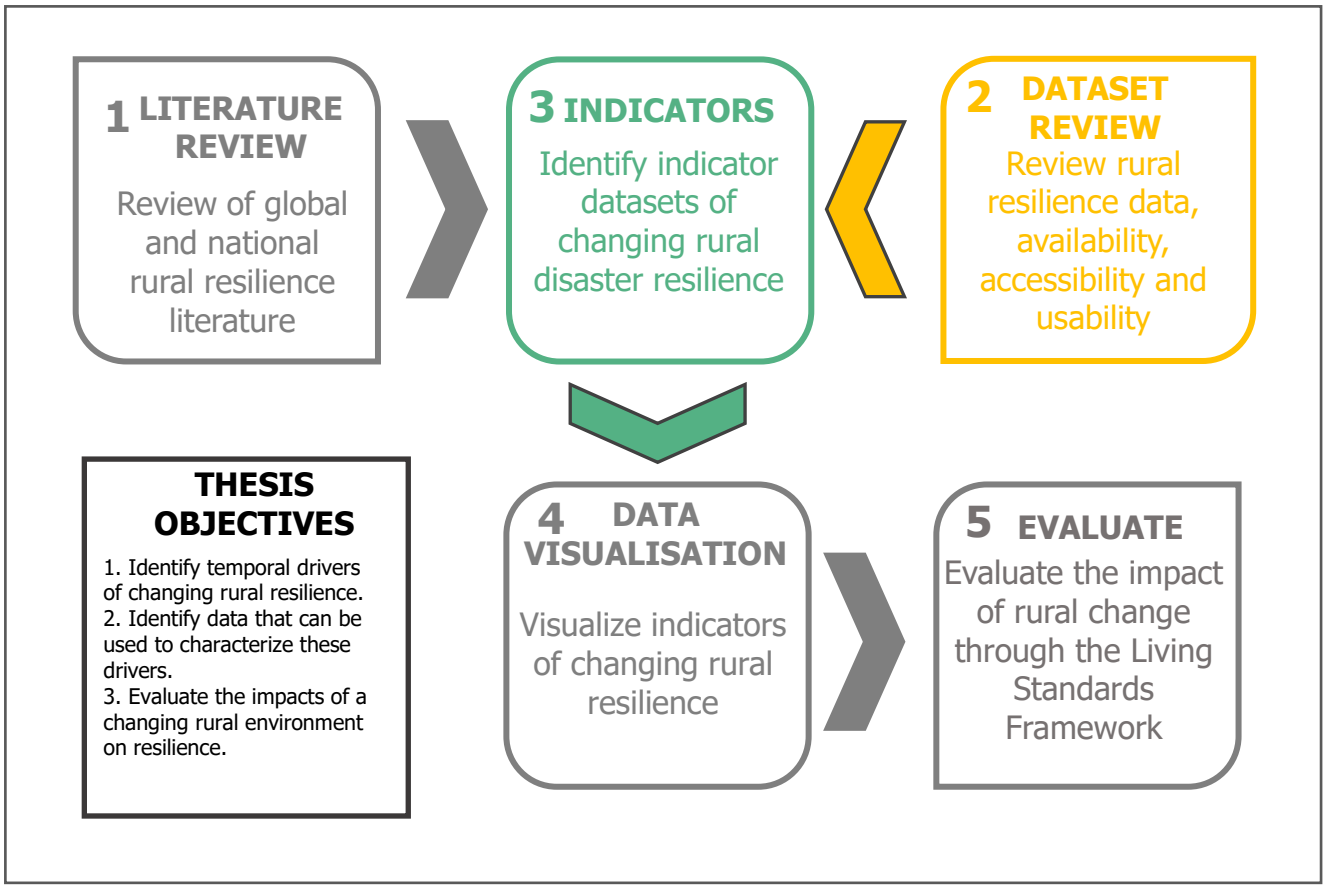


Figure 3.1 Chapter Three Methodology

This chapter begins with an overview of the data landscape in New Zealand and indicator data. Following this is a review of available datasets, grouped by rural

resilience themes identified through the literature review in Chapter 1; societal, environmental, economic and technological. The chapter concludes with a suite of indicators of rural change, informed by both the literature and the data review.

3.2 Indicator Data

Resilience should not always be reduced to a methodological problem, given that resilience operates within a complex system of responsibilities and governance (Prior & Hagmann, 2012). However, Cutter et al. (2014) notes that despite an array of literature on disaster resilience, there remains considerable disagreement as to the frameworks best for measuring it, therefore there is a lack of integration in resilience assessments from place to place. This disconnect also means that there is no single way to adequately characterise pre disaster resilience drivers in communities (Cutter et al., 2014). This lack of integration in accepted community resilience analysis contributes to an inability to reconcile disaster resilience frameworks with quantitative measures of community resilience (Cutter et al., 2014). Therefore, the use of indicator measures could allow comparative and long term analysis of resilience drivers as well as allow the identification of areas requiring intervention. Indicators can be defined as a way to characterise the basic elements of a system, addressing the challenge of characterising and quantifying resilience (Prior & Hagmann, 2012). Cutter (2010) recognises that indicators can be useful in assessments of risk, monitoring progress and change and including holistic aspects of resilience (Hall & Zautra, 2010; Nguyen & Wells, 2018). It is common for indicator schemes to focus on environmental, social and economic indicators as they are central to community resilience concepts (Wustenberghs et al., 2015; Kaye-Blake, 2019).

3.3 The New Zealand Data Landscape

This section aims to elucidate the key strengths and challenges to the use of research data in New Zealand. This provides the context in which the data review takes place. Significant value can be added to the socio-cultural, environmental and economic fabric of New Zealand through the use and application of data (Statistics New Zealand, 2018b). New Zealand has a rich data landscape, both the government and private

sector uses, holds and collects a vast number of data assets, ranging from scientific and environmental, to business and personal data (Statistics New Zealand, 2018b).

The New Zealand Data Strategy (NZDS) notes that there is increasing demand for data across New Zealand and aims to provide a direction and strategy for organisations to work towards. (Statistics New Zealand, 2018b). The NZDS identifies some key challenges within the data landscape including a lack of visibility around what data is available, as well as issues with accessibility and cost (2018b) (Figure 3.2).

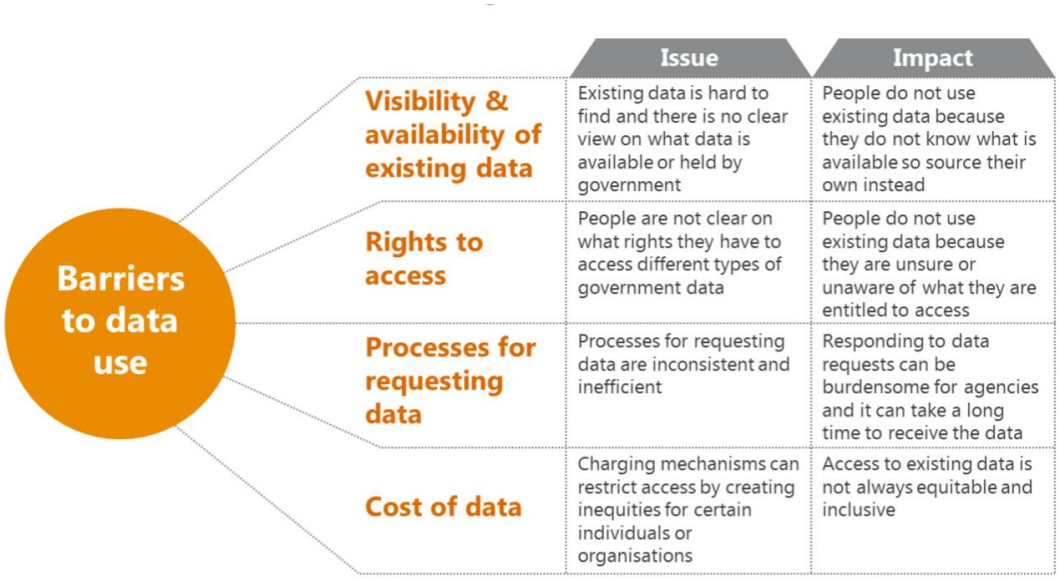


Figure 3.2 Barriers to Data Use in New Zealand (Statistics New Zealand, Data Strategy and Roadmap, 2018b)

Additionally, data capability gaps contribute to both barriers to data use, and underutilisation of data itself. Figure 3.3 presents the key data capability gaps in New Zealand. The NZDS identifies that there is a gap in maximising research data for decision making, with decision makers and policy makers unaware or without the skills to maximise their use of data. Furthermore, the NZDS notes that a lack of data translators to bridge communication gaps between data practitioners and decision makers contributes to inconsistent data practices and underutilisation. Addressing this gap will foster decision makers that are data literate (Statistics New Zealand, 2018b).

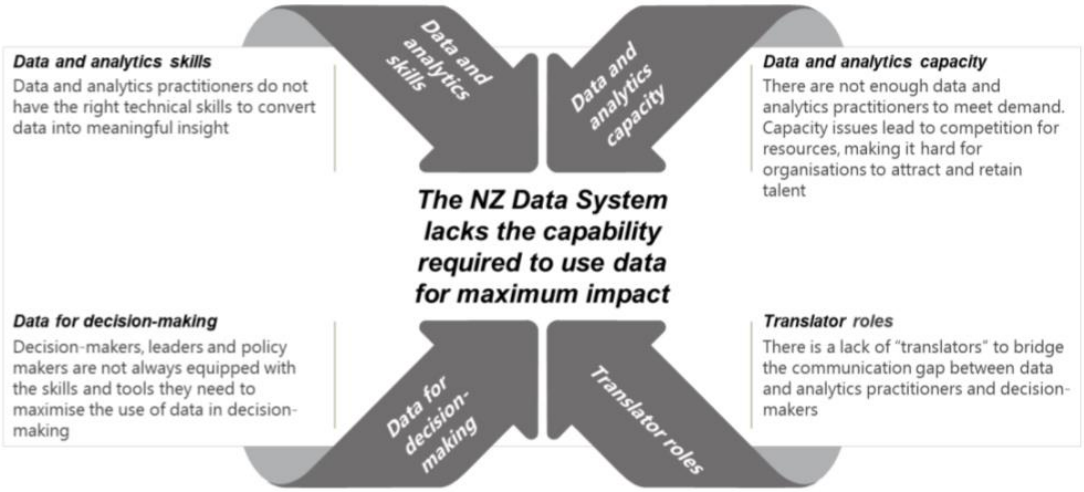


Figure 3.3 Utilising Data in New Zealand for Maximum Impact (Statistics New Zealand, Data Strategy and Roadmap, 2018b)

The nature of the DRR environment also contributes to inefficient use of data for rural disaster decision making. The use of data for resilience based work in New Zealand can be hindered by knowledge gaps and research siloes (Spector et al., 2018; Stevenson et al., 2017). These factors contribute to broader issues of research data availability, accessibility and usability. These issues create gaps where critical data is not available to decision makers.

Issues relating to accessibility, availability and usability challenge data use on a global scale, and within New Zealand (Cai & Zhu, 2015). This extends into research and decision making in New Zealand, where, despite a wealth of available data; time, budget constraints and organisational siloes hinder data use. Further challenges occur when data is stored in formats that are inaccessible without the use of technology or disciplinary expertise. Rapid advancements in data growth and technology (such as the development of GIS) have also changed the research data landscape (LINZ, 2016).

The NZDS is working towards building transparency and addressing availability in the research data landscape through four main objectives; investing in data, growing data capability and good practice, building partnerships and implementing transparent practices (2018b). This is supported by a number of policies, including the New Zealand Government Open Access and Licensing Framework (NZGOAL) and the New Zealand Open Data Charter (LINZ, 2015). Significant value can be added to the socio-

cultural, environmental and economic fabric of New Zealand through the use of geospatial data. However, engaging with end users, stakeholders and decision makers is vital to raise awareness about the value of data (Statistics New Zealand, 2018b).

3.4 Establishing Data Quality

This section outlines the data quality standards used to select potential indicator datasets in this research. Land Information New Zealand (LINZ) defines data as "*information in raw or unorganised form that refers to, or represents, conditions, ideas or objects*" (2016). Significant technological change in the 21st century has driven the collection of a huge quantity of data and extensive research (Cai & Zhu, 2015). However, poor data quality can lead to inefficient utilization of data for research and policy, and poor decision making (Cai & Zhu, 2015).

Data quality issues can stem from issues of accessibility, availability, duplication, and usability. Vast amounts of data are collected, however the complexity and magnitude of data poses a challenge for research science (MacEachren & Kraak, 2001). Data is collected in many different ways and formats and whether is fit for purpose depends on key factors such as data resolution, accuracy and frequency of measurement. A disconnect between what end users of information need, and what providers of data are delivering, and also problems of duplication of data across multiple agencies further contribute to data quality issues. Additionally, data can be stored in formats that are inaccessible without technology or disciplinary expertise (LINZ, 2016).

Cai and Zhu (2015) note that big data is a relatively recent concept, thus academia has not made a uniform definition of data and quality criteria. Therefore, they propose five data quality standards that can be used to assess potential research datasets in Figure 3.4. The five data quality dimensions and associated data quality indicators offer a robust way of assessing whether data are fit for purpose by addressing issues such as usability, reliability and availability for potential users. Potential indicator datasets are assessed using these data quality dimensions, to establish whether they are fit for purpose.

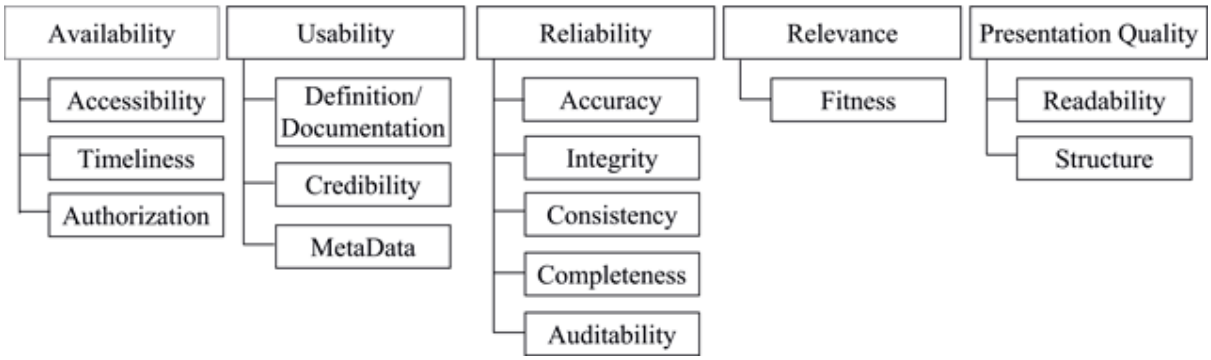


Figure 3.4 Widely Accepted Data Quality Dimensions and associated Data Quality Indicators for the use of Data in Research (Cai & Zhu, 2015)

Figure 3.5 presents the incorporation of these standards into the research methodology. To assess whether these datasets were fit for purpose they were required to:

- Show national level change
- Temporal scope
- Credible
- Accurate
- Relevant to rural disaster resilience

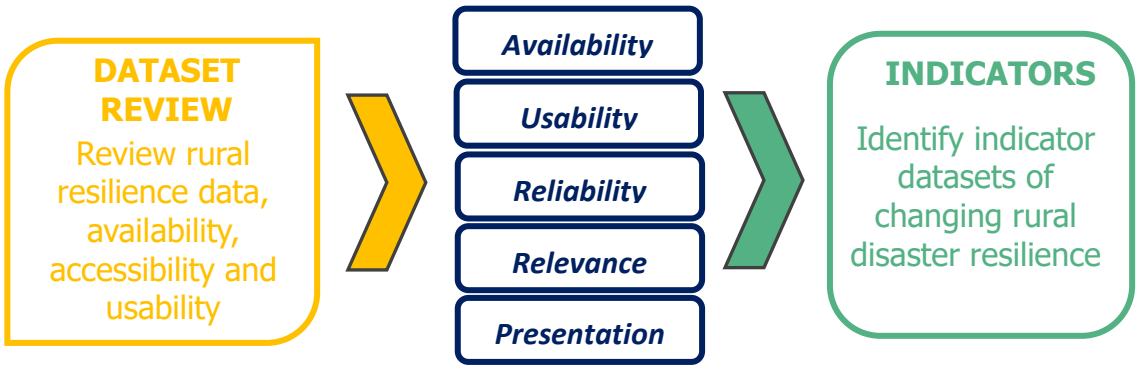


Figure 3.5 Incorporation of Data Quality Dimensions in the Research Methodology (Adapted from Cai & Zhu, 2015)

3.5 Data Review

This section outlines the main repositories of research data used in this data review. Most national level, publicly available government data is held in several key repositories (Figure 3.6). Data is also held by individual government departments and

private organisations. Government held data is accessible through a portal called https://data.govt.nz/ which has over 3,700 data sets, including data on agriculture, education, health and justice (LINZ, 2015). Statistics New Zealand (the government's official data agency) holds population, economy and societal data, and has a number of data portals including Infoshare (long term data series), and the NZDotStat Portal (table builder). Additional data is held in repositories including Koordinates, Manaaki Whenua Landcare Research Datastore, and Land Information New Zealand (LINZ). Additional data for this research was located through Historical Societies, research articles, Official Information Act Requests, and physical documents including atlases and maps. An outline of data sources searched in the Data Review is provided in appendix B.1.

Figure 3.6 Repositories of Data in New Zealand

The following sections presents the results of a review of available rural data. Indicator datasets have been selected based upon the results of the literature review and a set of data quality parameters, outlined in Section 3.4. The following sections outline

indicator datasets grouped by societal, environmental, economic and technological trends.

3.5.1 Limitations of Data Review

The results of the following data review do not represent an all-encompassing review of all rural data, however, if datasets were unable to be found, used and analysed, they are effectively unavailable for rural decision makers to utilise. Datasets have been excluded where the geographical and/or temporal range is inappropriate and if they do not meet data quality standards. Specific limitations for each dataset are outlined in section 4.0.

3.6 Societal Trends

Societal trends of rural resilience are complex, and context specific. In the literature, commonly identified drivers of social change include factors such as population change, demographic change, and changes to the rural environment, like the loss of service providers like banks and schools (Amundsen, 2012; Race et al., 2010; Kearns, 1991; McGranahan & Beale, 2002). Service providers such as banks, schools and post offices in rural communities serve are noted as important markers of community memory, identity and function, making important contributions to social networks and community life (Coster, 1999; Kearns, 1991; Witten et al, 2003).

A review of available data indicated that data related to population change, migration and associated demographic change, is available through Statistics New Zealand. Data for lifestyle blocks is held by Agribase, and school and hospital closure data was located through the Ministry for Health and Ministry for Education. The data review indicated that there is a relative lack of data that spatially represents rural service change. For example, whilst data for some years exists pertaining to school closures, it is held in a format that is not spatial or geolocated. This had to be done before the data could be visualised on a map. This is a key barrier for many decision makers. Additional challenges occur with other datasets, such as post office closures. While this data is held by Archives New Zealand, it is not digitised and sits behind a paywall.

In examples such as these, this hindered data visualisation and analysis. Potentially due to the contextual nature of this data, it did not lend itself to high level analysis, and whilst an important aspect of rural resilience, is hard to capture at the national level. Figure 3.7 displays the results of the data review for societal drivers of resilience. Data sets have been excluded where they do not meet data quality standards outlined in *Section 3.4*.

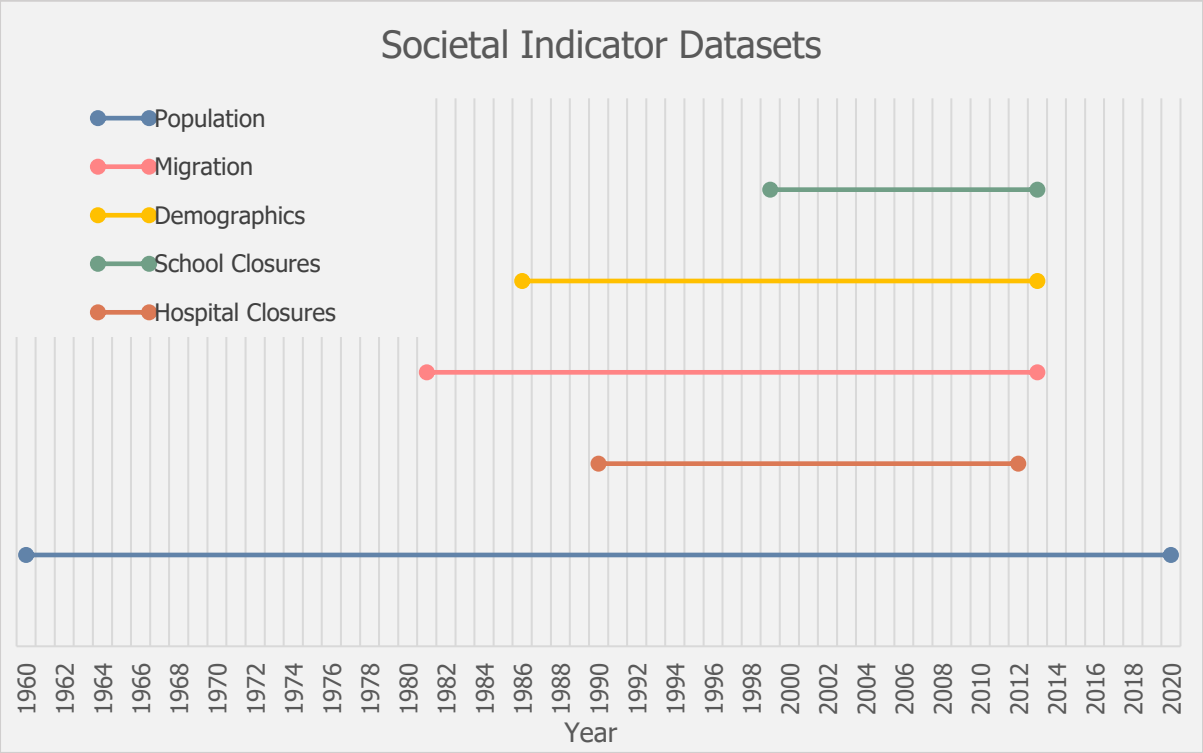


Figure 3.7 Societal Indicator Datasets

3.7 Environmental Trends

Environmental trends drive changing resilience. In the literature these include factors like changing climate and natural hazard impacts, as well as factors like land use change, farm intensification and diversification (Panelli et al., 2003; Pomeroy & Newell 2011; McManus et al., 2012). A review of available data indicated that a significant amount of agricultural data is available, particularly for land use change, farming types and livestock numbers. Although climate data for drought indicators such as soil moisture deficit is available, there were few long term datasets pertaining to declared drought in regions, perhaps due to the often localised nature of the data, necessitating

the building of one from beehive release announcements. The data review indicated that there is a lack of non-agricultural rural data, such as land use change in rural areas pertaining to tourism or lifestyle activities. Figure 3.8 presents the results of the data review for environmental datasets. Datasets have been selected according to data quality standards outlined in Section 3.4.

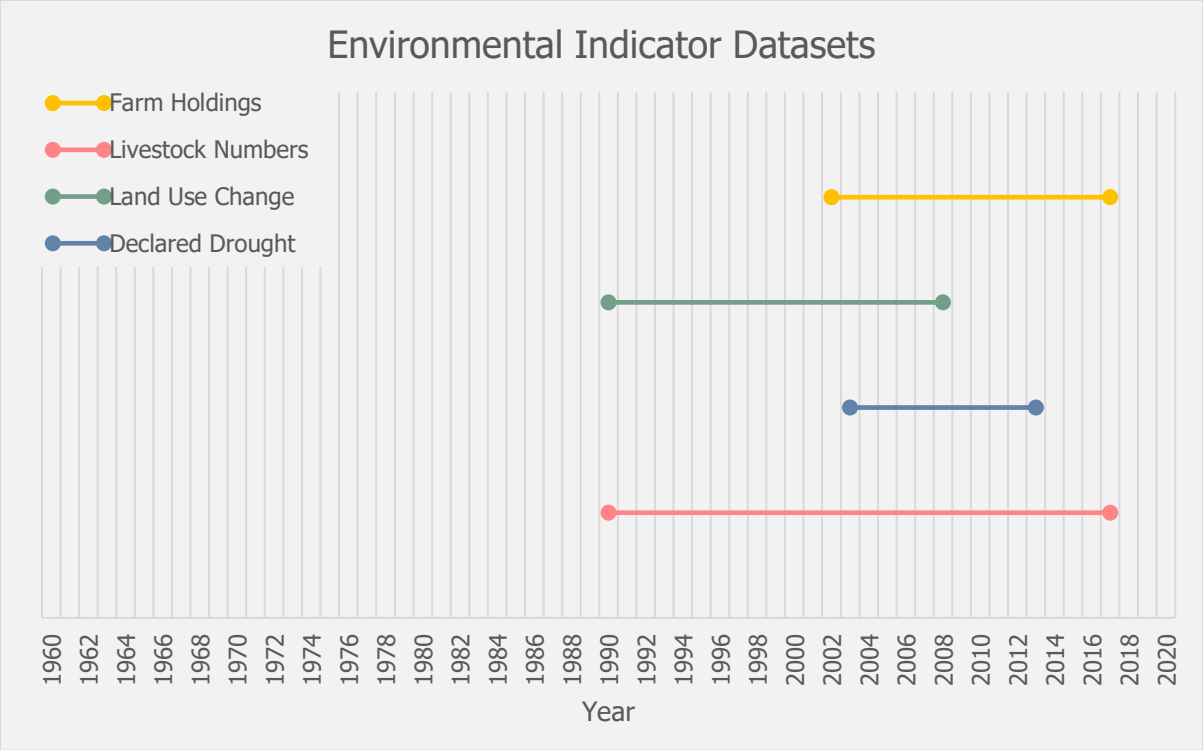


Figure 3.8 Environmental Indicator Datasets

3.8 Economic Trends

The literature review indicated that economic trends are an important factor in changing resilience in rural communities. Wickes et al. (2015) note that pre disaster economic stability is an important factor in post disaster outcomes. Pomeroy and Newell (2011) emphasise that a strong and diversified economic base is one characteristic of a resilient community. Drivers of economic trends include rural economic restructuring and associated changing rural economic activity and community change (Donner & Rodriguez, 2008). A review of available data in New Zealand revealed a wealth of economic data, such as GDP and productivity statistics. It was however more difficult to find data that referred specifically to rural economy

outside of agricultural parameters, such as rural tourism. Figure 3.9 presents the results of a data review for economic indicators.

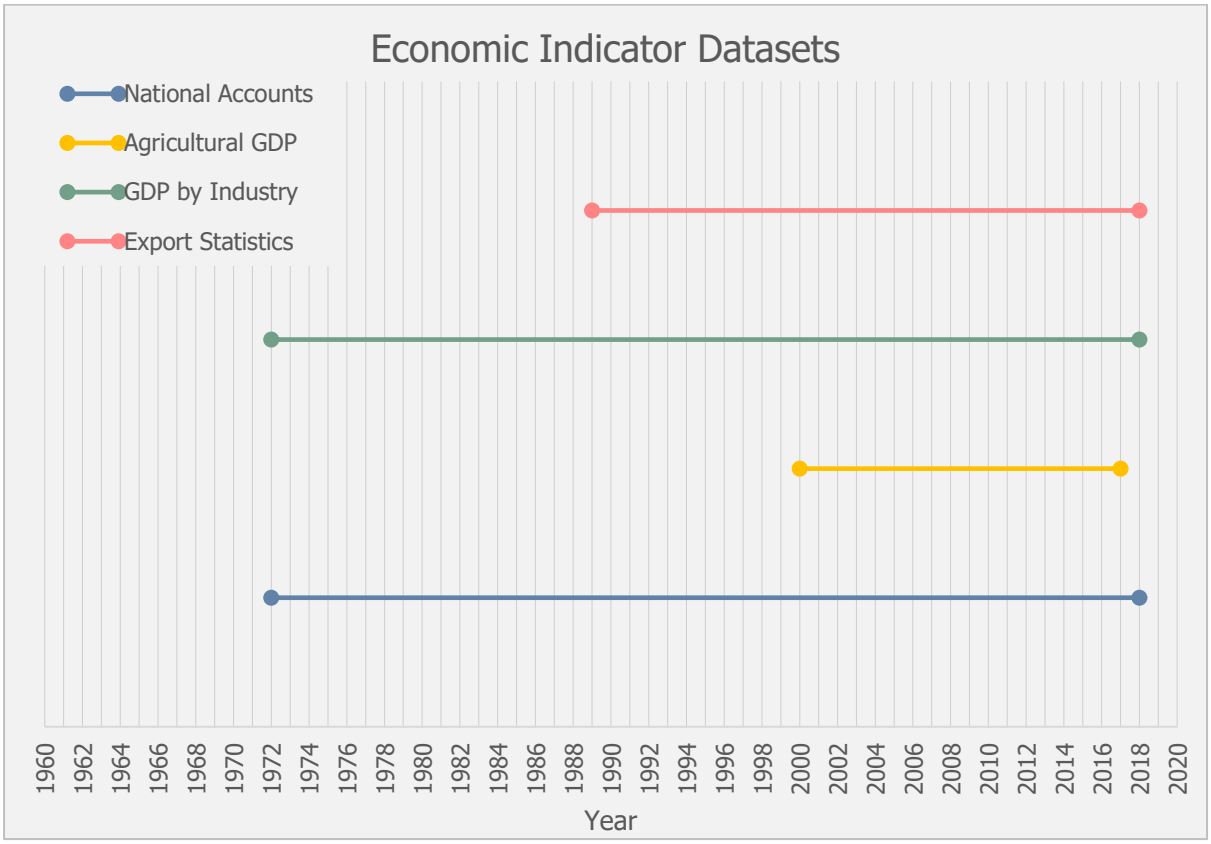


Figure 3.9 Economic Indicator Datasets

3.9 Technological Trends

Many technological trends in rural communities are more recent, thus there are fewer long term datasets for technological change. The literature review indicated that technological changes, like the development of irrigation technology and broadband access, could drive changing resilience in rural communities (Frieling & Warren, 2018; Heesen et al., 2013; Roberts et al., 2017). In New Zealand, investment in irrigation technology and infrastructure has allowed farm intensification and conversion to higher value land uses such as dairying. Another example of technological change is an increase in the availability of broadband and telecommunications in rural areas, which has enabled access to services such online banking, however, has hastened the decline of physical service presences in communities (Frieling & Warren, 2018). Future technological trends are also an important consideration for rural resilience. Innovation in agricultural practice could improve agricultural outputs, while climate

change mitigation may require future adaptation technologies (Viviano, 2017). The results of the data review indicate three indicator datasets for technological change. These include broadband access, irrigation and agricultural research and development. A limitation of these data sets is the limited length of time they cover when compared to other datasets, however, this could related to the nature of technological change, which is typically more recent. The results of the data review are presented in Figure 3.10.

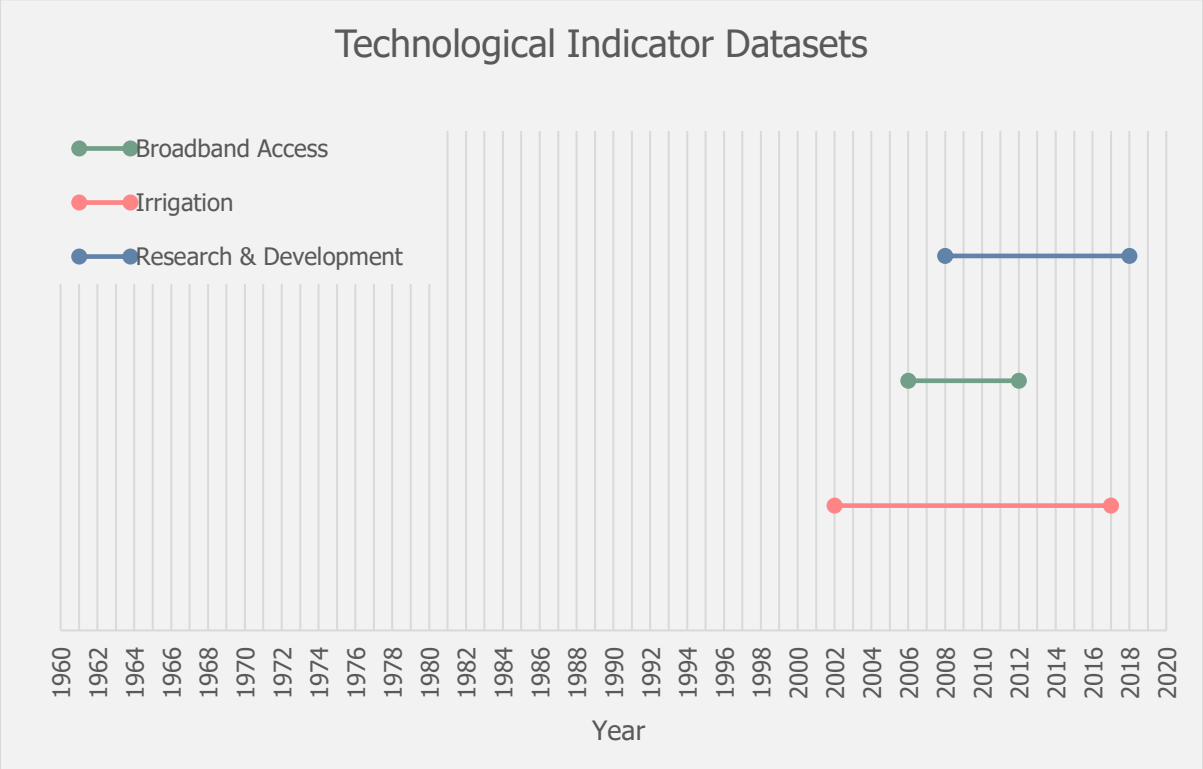


Figure 3.10 Technological Indicator Datasets

3.10 Visualising Indicator Datasets

MacEachren and Kraak (2001) state that visualisation is the key to turning data into knowledge. This section outlines the science communication concepts that guided the visualisation of indicator datasets in this research. Firstly through a review of effective science communication, followed by an outline of using Geographic Information Systems (GIS) for indicator visualisation.

Science communication has a multitude of definitions and applications, but at its core it is the process of communicating scientific knowledge to a range of audiences in a

way that is engaging and effective (Burns, O'Connor & Stocklmayer, 2003; Illingworth, 2017). The science communication field is underpinned by a contextual methodology that explores the interaction between science and its audience, and promotes public understanding as the joint creation of science and local knowledge (Burns et al., 2003; Miller, 2001). Effective science communication is becoming more enmeshed with science practice itself, with scientists increasingly expected to communicate their research findings to a wider audience in an engaging and effective manner (Illingworth, 2017; Bryner et al., 2012).

Effective DRR communication is also required to overcome disciplinary siloes (Bryner et al., 2012; Chmutina & Bosher, 2015). Disciplinary and organisational silos have been identified as working against building resilience (Bryner et al., 2012; Fenwick, Seville & Brunsdon, 2009). In Nepal, poor dialogue between DRR practitioners and scientists was found to lead to poor translation of earthquake science into DRR policy and practice (Oven et al., 2016). The authors identified that better dialogue and communication tools, guided by stakeholder needs could improve the overall reduction of seismic hazard risk in Nepal. Chmutine and Bosher (2015) found that in Barbados, more effective DRR communication is required to improve uptake of DRR methods, and this communication must be accessible to a range of stakeholders.

In New Zealand, where the hazard research context is well established, channelling science into meaningful action can be challenging. Dialogue between science and policy requires effective communication, and the communication of science for disaster risk reduction is vital for scientific information to be applied (Bryner et al., 2012). Engaging in science and risk communication is an important component of disaster risk reduction. However transitioning this knowledge from a concept into meaningful action is challenging (Weichselgartner & Kelman, 2014). Edwards et al. (2012) highlight the need for greater dialogue, understanding and collaboration if research is to be put into practice and generate impacts. The National Disaster Resilience Strategy (MCDEM, 2019) also highlights the need to develop methods for showing the impacts of decision making on resilience (Basher, 2016; Kay et al., 2019).

Application of scientific knowledge relies on the engagement of practitioners in scientific research, which can be difficult to understand and user unfriendly (Edwards, Fearnley, Lowe & Wilkinson, 2012). Additional challenges include understanding risk and scientific uncertainty, stakeholder perspectives and the different capacities of stakeholders to meaningfully engage with research (Edwards et al., 2012). As a result, natural tensions between research and policy application exist, particularly around separate goals of scientific accuracy and political relevance (Beaven et al., 2016).

Somewhat addressing this tension is effective science communication. Fostering dialogue could improve future disaster outcomes. Science communication is a key tool for overcoming the challenges of understanding science for stakeholders, and ensuring research is relevant, usable and used. Cole and Murphy (2015) emphasise the need for DRR communication strategies specifically designed for rural communities, and in particular, rural decision making (Bryner et al., 2012). In DRR, a multitude of communication strategies can be used including, stakeholder engagement, workshops, community based planning and scenario development (Williams & Dunn, 2003; Krishnamurthy, Fisher & Johnston, 2011; Kemp, 2008; Barclay et al., 2008). UNDRR notes that technological advance in recent years have vastly improved the ability of researchers to communicate scientific information to stakeholders, such as through GIS (Prevention Web, 2015). Effective communication not only helps experts develop and share data but also allows communities to understand and take actions to reduce their own disaster risk.

3.11 Geographic Information Systems

GIS can be a powerful tool for supporting DRR efforts (Rurup, 2017). Effective GIS facilitates effective communication of DRR information, not just as a mapping tool but as a way of integrating data, and knowledge transfer (Barclay et al., 2008; Kemp, 2008; Krishnamurthy et al, 2011). Additionally, Rosenbaum & Caulshaw (2003), identify that there is scope for GIS to analyse socioeconomic data alongside hazard data to build more constructive, participatory dialogue and guide decision making. Williams and Dunn (2003) note that using GIS in participatory research by juxtaposing

spatially referenced data with indigenous geographical knowledge enabled improved spatial decision making. However, challenges to utilising this technology can include cultural, political and social barriers. Additionally, a critical barrier for the use of GIS is the availability and investment in data collection and GIS programmes. Rurup suggests these problems could be countered by integrating GIS and DRR into organisational structures and clearly demonstrating the benefits of GIS for decision makers (2017).

MacEachren & Kraak (2001) state that the use of GIS can turn large volumes of data, into interpreted data, and therefore into knowledge. They state that the challenge of inherently complex and interdisciplinary problems (like population vulnerability) could be met with geospatial visualisation, which provides a fundamental method of linking diverse forms of data (MacEachren and Kraak, 2001). The nature of data visualisation techniques such as GIS means they also contribute to a synthesised methodological approach, bringing together different avenues of knowledge to build a cohesive picture of rural change (Berkes & Ross, 2012).

4 RURAL NEW ZEALAND CHANGE

4.1 Introduction

This chapter presents the results of stages 1-3 of the methodology, with visualisations of indicator datasets. Results are presented grouped by societal, technological, environmental and economic. This chapter is stage four of the research methodology, outlined in Figure 4.1; Visualise indicators of changing rural disaster resilience.

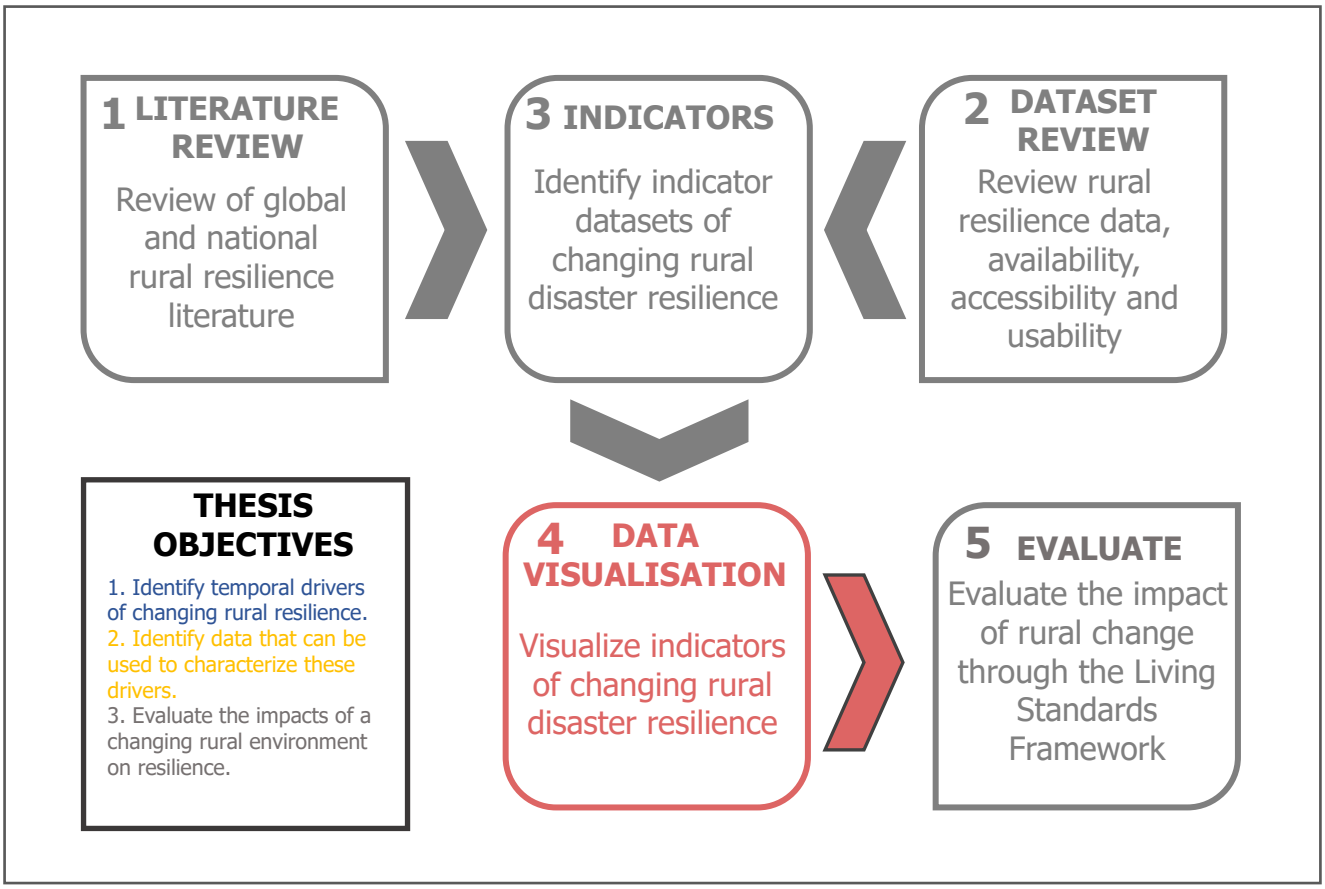


Figure 4.1 Chapter 4 Research Methodology

This section aims to identify at a national level, what has changed in rural New Zealand using a range of available data and geospatial visualisation. Due to the complexity of a context like changing rural New Zealand, with drivers including political forces, demographic and economic change, this section primarily focuses on *what* has changed rather than *why*.

4.2 Societal Trends

Societal trends of changing rural resilience are highly complex, and context specific. In the literature, commonly identified drivers of social change include things like population change, demographic change, and changes to the rural environment, such as the loss of service providers like banks and schools (Amundsen, 2012; Race et al., 2010; Kearns, 1991; McGranahan & Beale, 2002). The results of a data and literature review produced six indicators of societal change:

- Population Change
- Migration
- Rural Demographics
- School Closures
- Hospital Closures
- Lifestyle Block Growth

4.2.1 Population Change

Overall rural population numbers in New Zealand have not changed dramatically since the early 20th century despite strong growth in urban centres. Statistics New Zealand have made attempts to quantify rural and urban differences in population, but this has been complicated by changing definitions of what constitutes urban and rural (RCG, 2018). The rural population hovered around 500,000 in 1916, and by 2001 this had increased to just 532,740 (Fraser, 2006; Pink, 2004). However this belies the extent of change that took place following the end of World War Two. In the early 20th century almost all of the Maori population lived in rural areas with just 10% of the Maori population living in urban areas. Following the end of World War Two, urban drift pushed this proportion to over 30% by the 1960s (Fraser, 2006; RCG, 2018). While the urban population grew by 1,500% the rural population grew just 83% between 1881 and 2001 (Ministry of Health, 2011). This is evident in Figure 4.2, where the proportion of the population living in rural areas has fallen from 32% in 1926, to 14% by 2006. Despite an overall constant rural population size, New Zealand has also experienced significant shifts in the geographical distribution of the population (Hall, 2006). This has had different regional impacts, Figure 4.3 highlights population change

since 1945. Areas including the Waimakiriri and Queenstown-Lakes District, show strong growth while population decline is evident in the Buller and Grey Districts. Much of this growth could be attributed to the growth of urban centres in these districts and could be obscuring sub-regional changes such as population loss in rural areas.

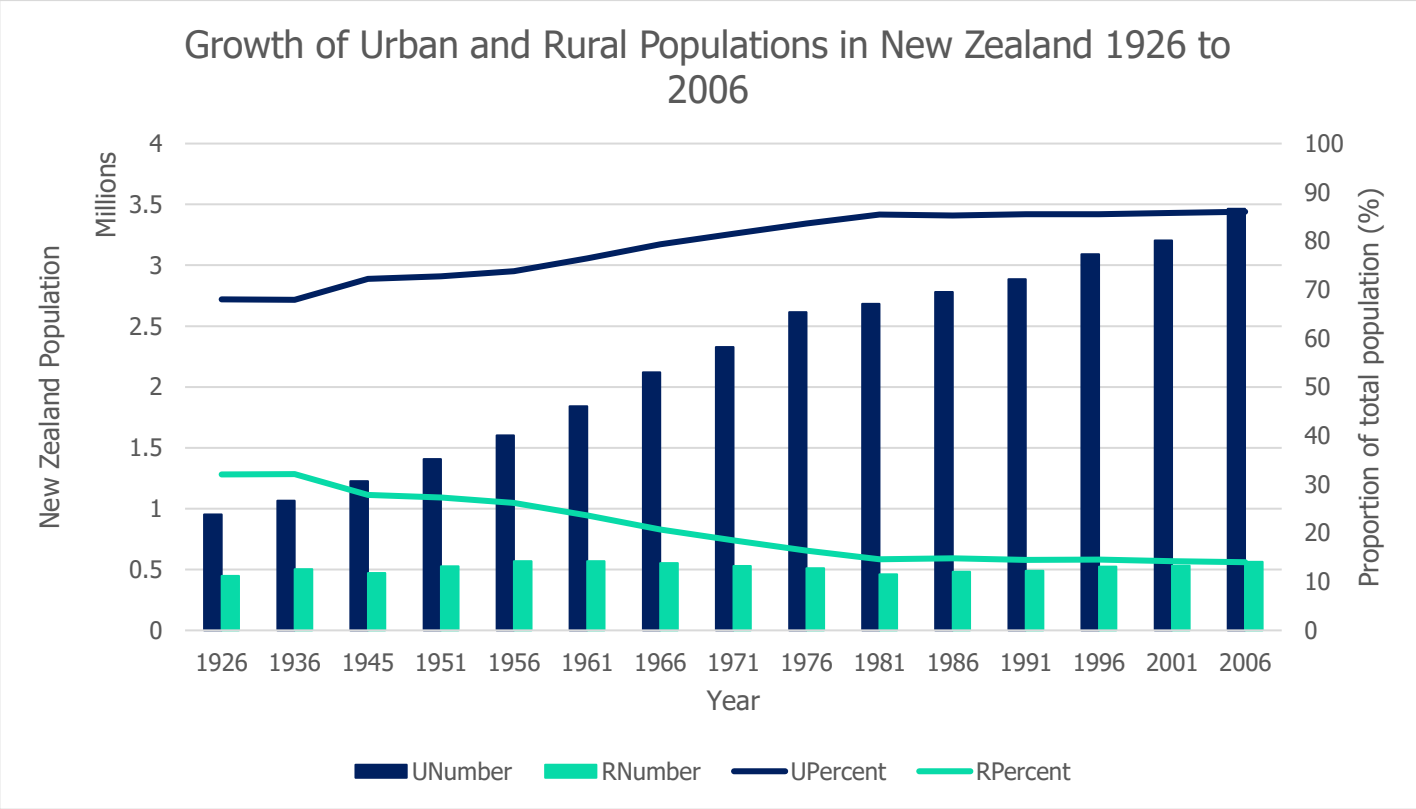


Figure 4.2 Growth of Urban and Rural Populations in New Zealand from 1926 to 2006 ('urban' is based on urban areas and towns with over 1,000 people, and 'rural' is the remainder. From 1981 onwards census usual resident population counts replaced census night population counts (Statistics New Zealand Official Yearbook, 2012a)

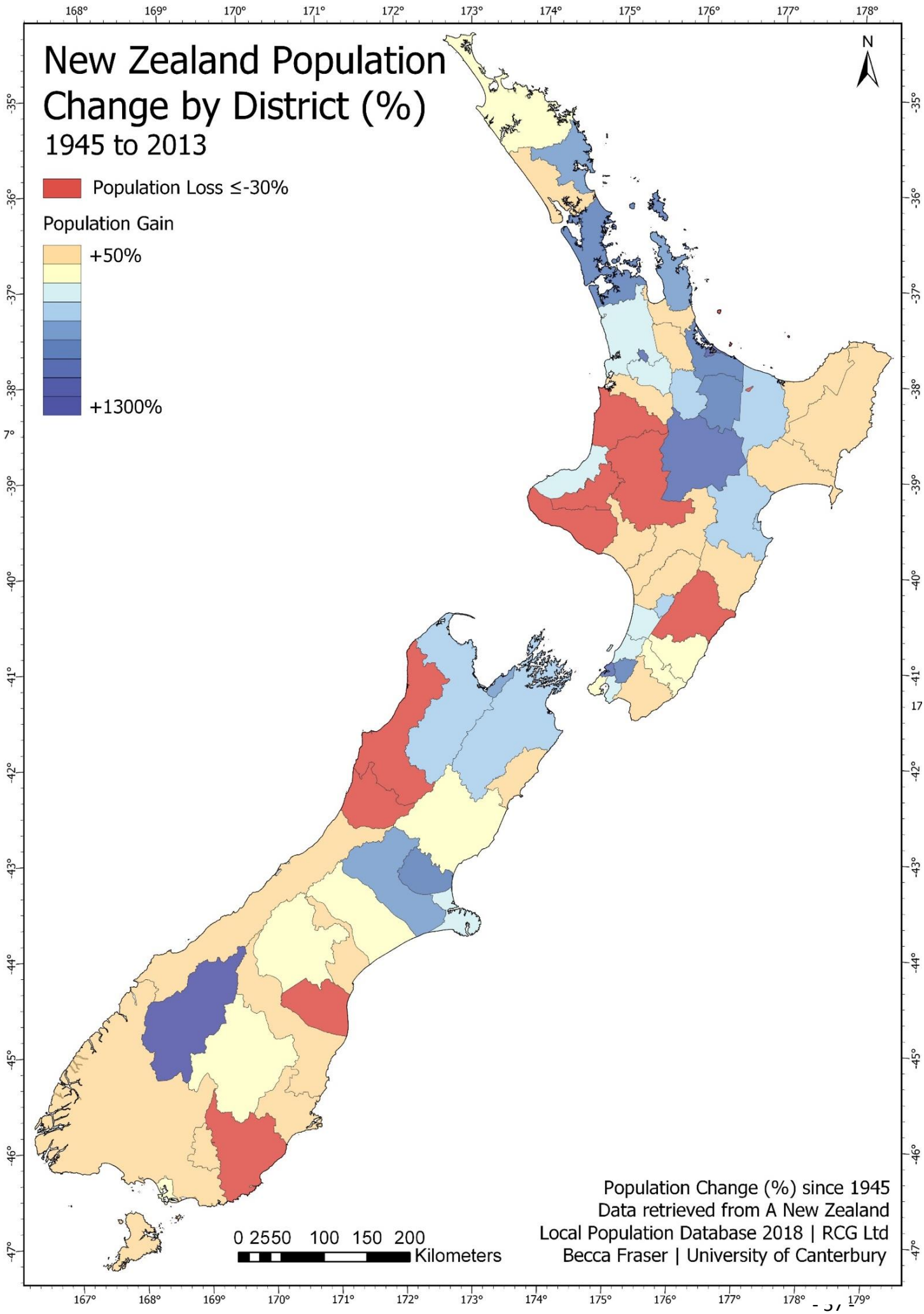


Figure 4.3 New Zealand Population Change since the end of World War II (RCG, 2018)

4.2.2 Migration

From 2013 to 2017, New Zealand experienced what some researchers have termed a 'migration boom', this is evident in Figure 4.4, net migration jumped from -3,191 in 2012, to 69,090 in 2016 (RCG, 2018; Statistics New Zealand, 2018a). At the subnational level, net migration estimates indicate that the biggest areas of growth were the Auckland Region (+36,152), followed by Christchurch City (+5403), Wellington (+2195), Hamilton (+1875) and Tauranga cities (+1052) (Statistics New Zealand, 2018a).

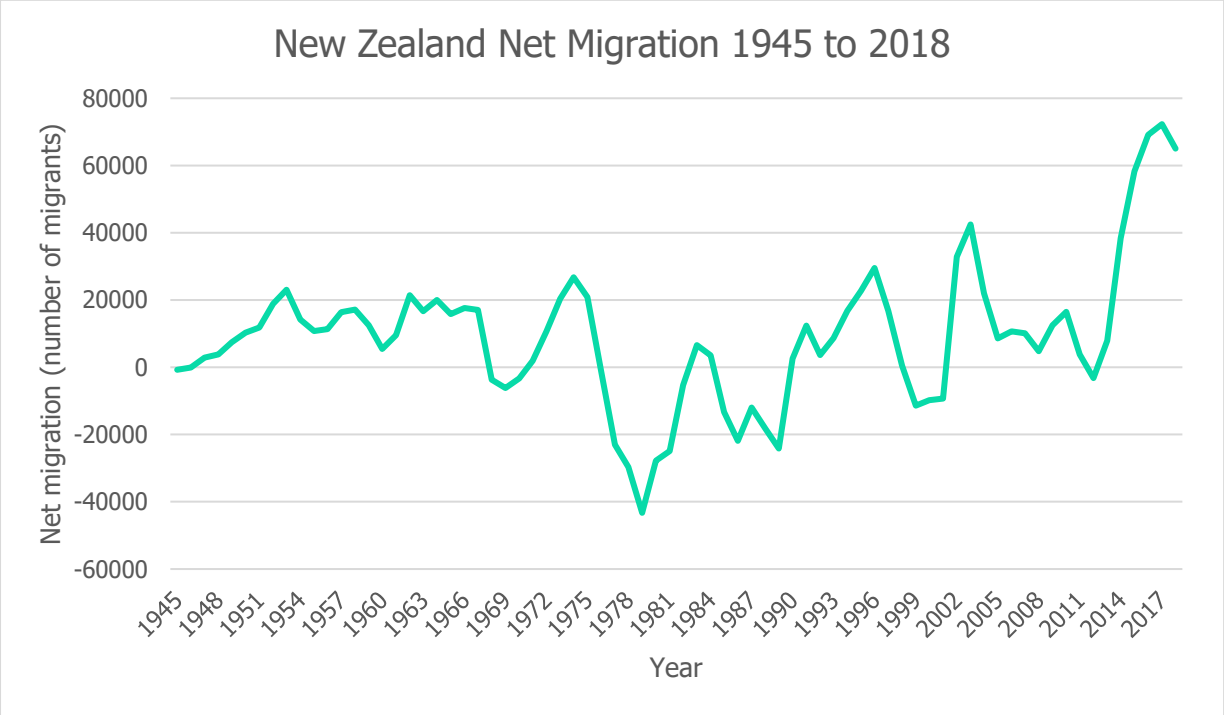


Figure 4.4 Net Migration in New Zealand from 1945 to 2018 (Statistics New Zealand Permanent & long-term net migration key series (Annual-Jun), 2018a)

Net internal migration between regional populations also helps discern geographic population movements. Figure 4.5 shows net internal regional migration between regions (excluding international migration) as a proportion of regional population. This indicates that regions including Gisborne, Hawkes Bay, Taranaki and the West Coast had consistent negative population loss from migration between 1981 and 2013. In contrast, the Bay of Plenty and Tasman have seen growing populations as a result of regional migration. Population loss in the Canterbury region between 2006 and 2012 could reflect the impacts of the Canterbury Earthquake Sequence and subsequent population loss to other regions. There has since been a recovery with population

numbers for Christchurch City growing by over 5,000 in 2017 *(Figure 4.5)* with the total population at 369,006 in 2018, up from 348,456 in 2006 and 341,369 in 2013 (Statistics New Zealand, 2016).

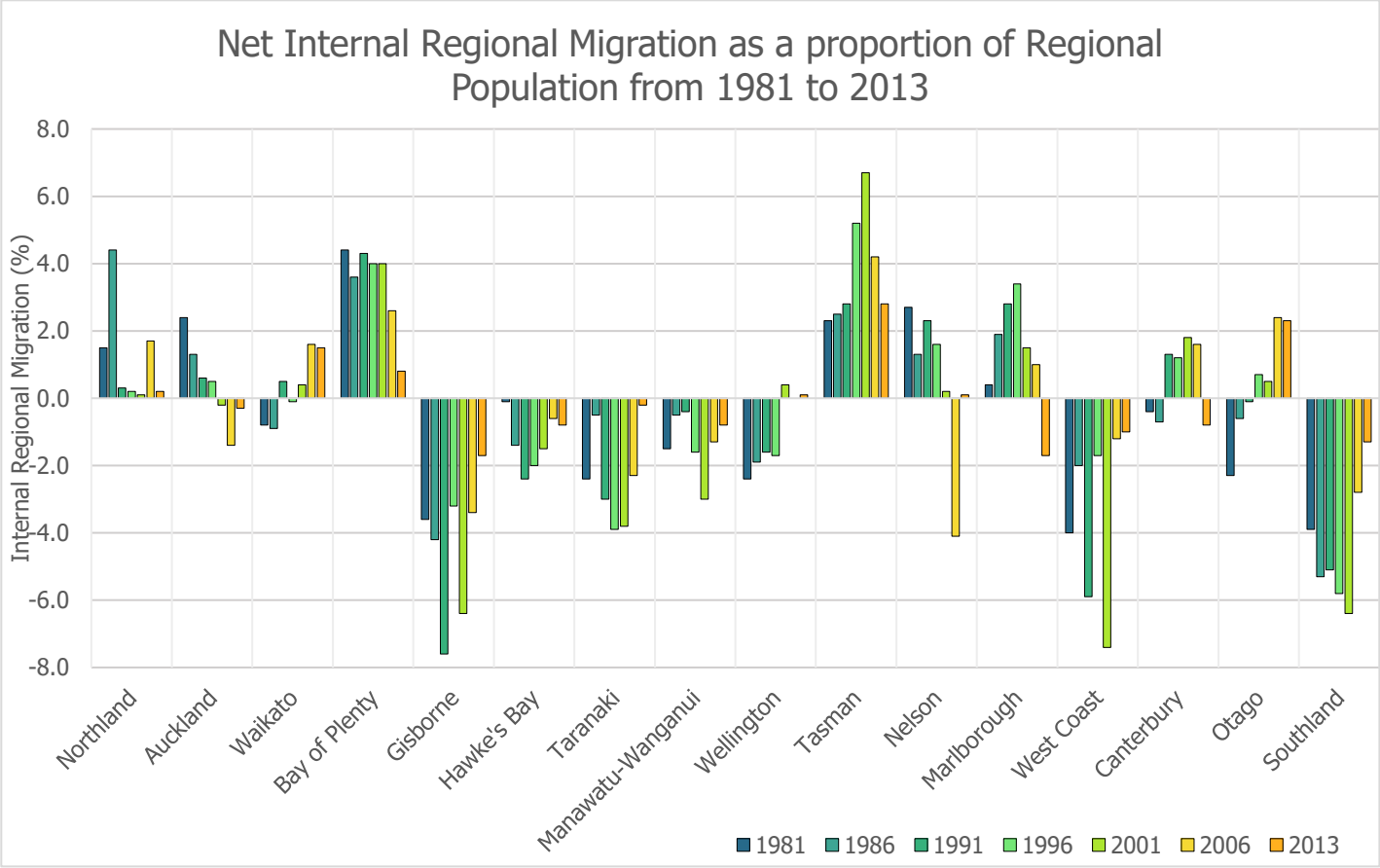


Figure 4.5 Net internal migration between New Zealand regions as proportion of regional population 1981 to 2013 (Statistics New Zealand Census of Population and Dwellings, 2016)

Population migration patterns have differed by urban/rural areas as well. Figure 4.6 indicates that rural areas with both high and moderate urban influence had the highest net population growth compared to all other areas between 1986 and 2006. Over this time period, rural areas with high urban influence had a net increase of 31,731 and rural areas with moderate urban influence had a net increase of 50,499 people. Independent urban areas and rural areas with low urban influence saw consistent net population loss over the same time period.

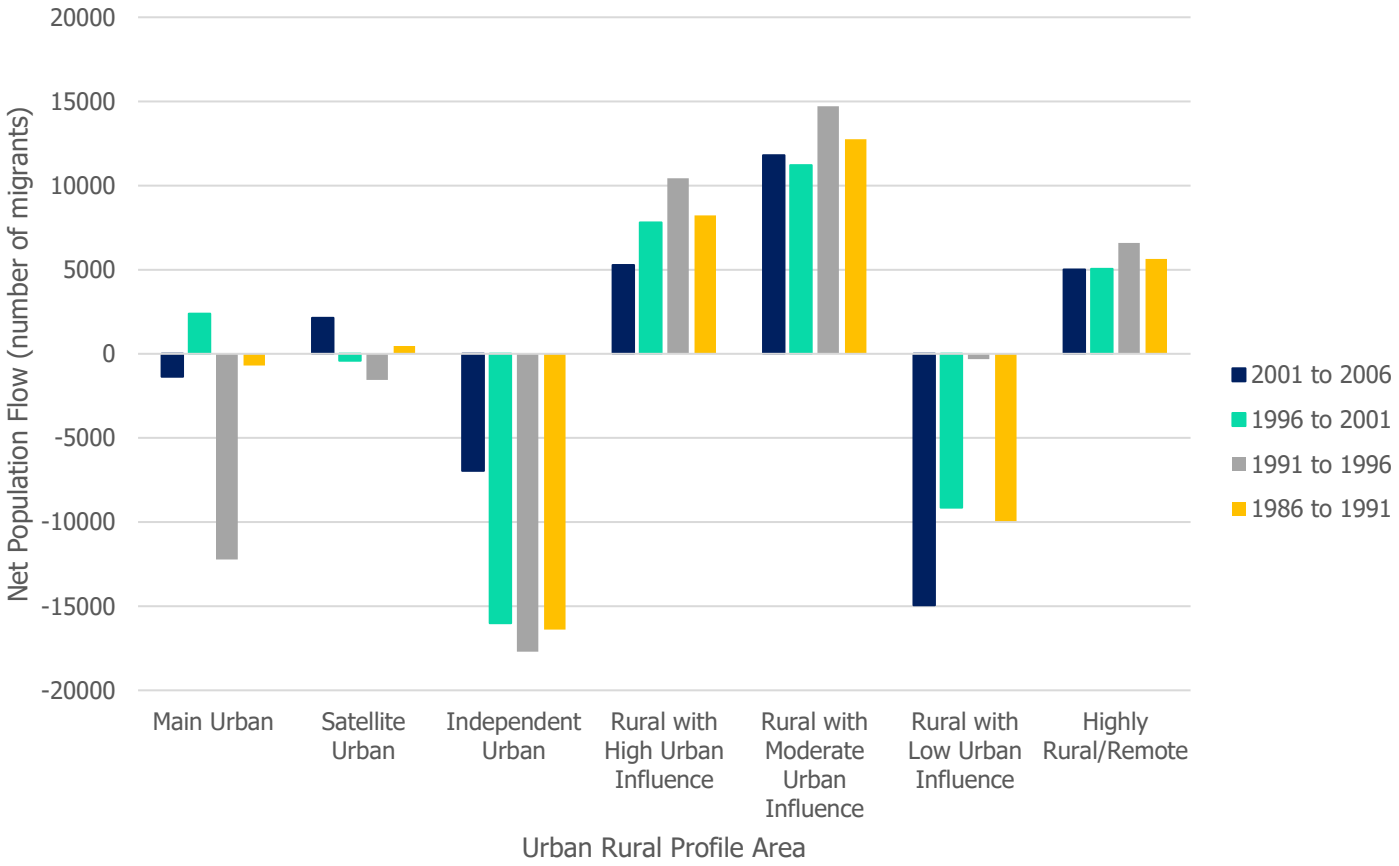


Figure 4.6 Net Population Movement by Urban/Rural Profile Area 1986 to 2006 (1991, 1996, 2001 and 2006 Censuses of Population and Dwellings, Statistics New Zealand, 2016)

From 1976 to 2013, migration patterns caused many rural centre and urban populations to have older age structures than would have been the case without migration (Jackson & Brabyn, 2017). Meaning, either migration of younger generations, or the addition of older generations has shifted demographic proportions in New Zealand. Statistics New Zealand identifies age as a key indicator of migration, with people in their early twenties tending to move from rural areas for education and employment. Migration rates in the 55-64 years age group also rise, potentially due to lifestyle/retirement movements (Statistics New Zealand, 2009). In the North Island, there has been significant retirement migration to coastal areas, particularly around the Bay of Plenty and Bay of Islands, in the South Island, this has been concentrated in areas including Banks Peninsula, Marlborough and the Tasman and Nelson regions (Hall, 2006). Figure 4.7, indicates a concentration of the population over 65 years of age in coastal areas and places including Northland and the Coromandel Peninsula.

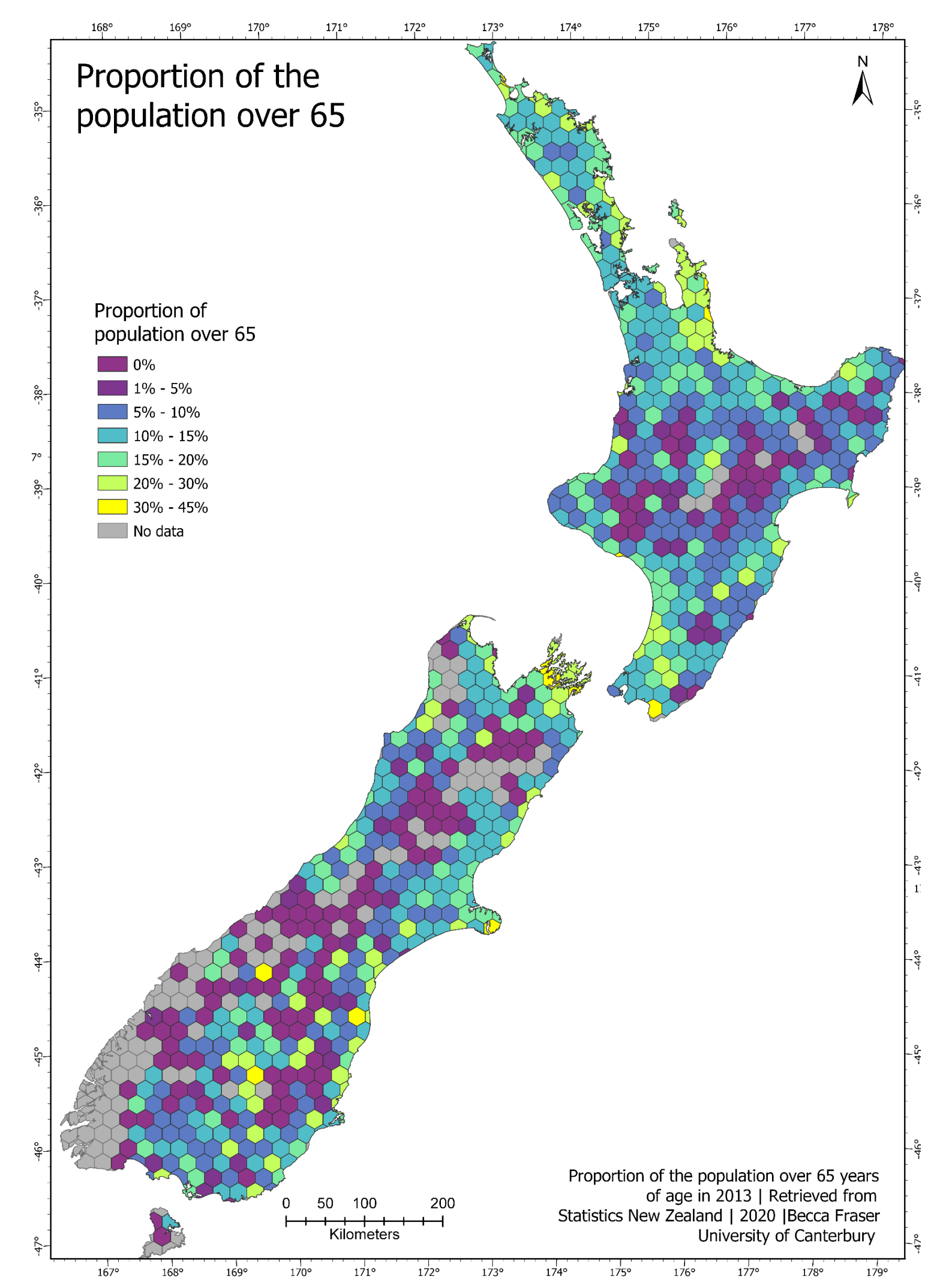


Figure 4.7 Proportion of the New Zealand Population over 65 years of age in 2013 (Statistics New Zealand, 2013)

4.2.3 Demographic Change

The median age of the population is trending older, from 34.8 years in 2001, to 38 years in 2013 (Statistics New Zealand, 2013b). The median age in rural communities is generally higher than urban centres, in part because of the loss of young adults to urban centre for reasons such as education or career opportunities. People aged 45-79 make up a larger proportion of the rural population than the urban population (Ministry of Health, 2011).

However, Jackson and Brabyn (2017) argue that far from the commonly presented 'decline' of small rural towns in terms of aging populations, this is not simply a rural phenomenon, and a myriad of factors influence the age of populations in communities such as shifts in geographical distribution through migration (Hall, 2006; Jackson & Brabyn, 2017). The view of an 'ageing rural population' is potentially driven by the movement of older generations to rural areas for retirement/lifestyle purposes. In 2004, the average age of these lifestyle block owners was 53 years (Cook & Fairweather, 2005). Cook and Fairweather (2005) also note that some lifestyle block owners may declare themselves as farmers, thereby increasing the average age reported in rural areas. Additionally, Fairweather and Mulet-Marquis (2009) noted that as the overall rural population decreased between 1981 and 2006, the average age of livestock and crop farmers rose from 40.8 to 46.5 years of age.

The rural workforce has also seen shifting demographic proportions. In 2006, 65% of the farming workforce was over 50, compared to 57% of the total workforce**.** In 2013 this dropped to 41% of the rural workforce over 50 years of age, compared to 35% for the total labour force (Figures 4.8 and 4.9). While the average age of farmers may be higher than the labour force average, research indicates that this may not be a new trend in farming, the propensity of farmers to keep farming well into their 60s has been documented by research (Fairweather et al., 2007). In Australia, a survey of 160,000 farmers found the average age to be 51 years, and also reported the average age for US and Canadian farmers was increasing (Fairweather & Mulet-Marquis, 2009).

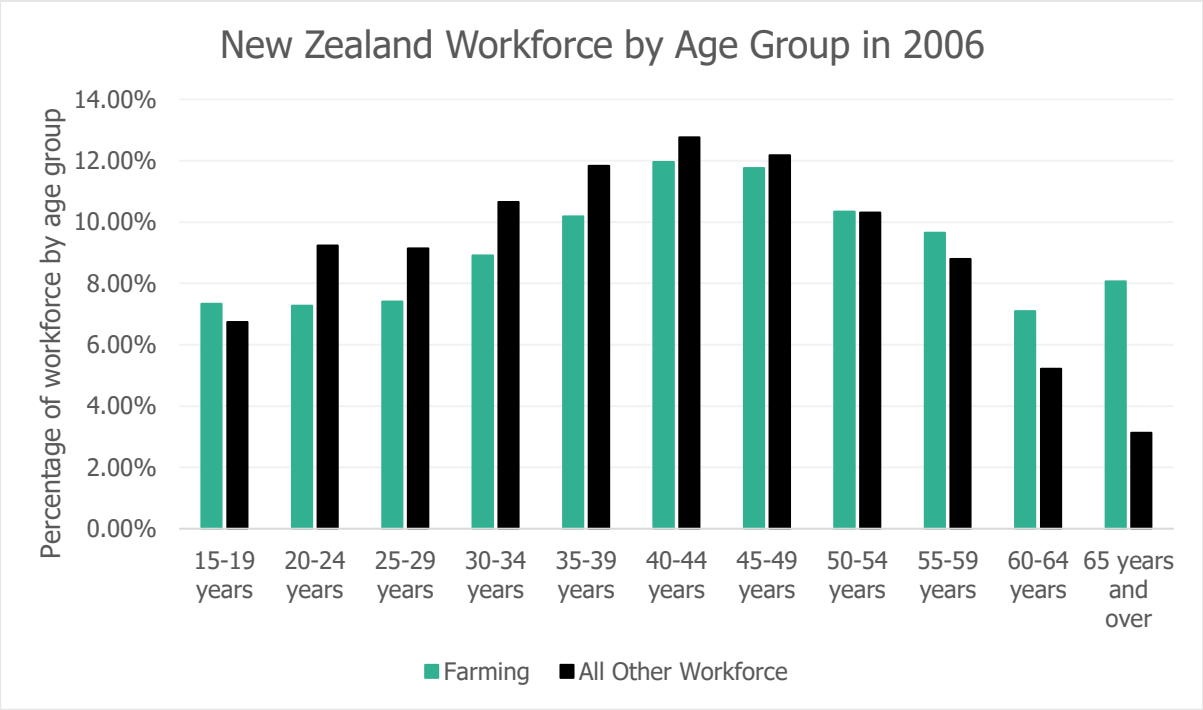


Figure 4.8 Workforce by age group in 2006 (Household Labour Force Survey, 2013c) (Rural workforce includes farmers, farm managers, skilled animal and horticultural workers as well as farm, forestry and garden workers)

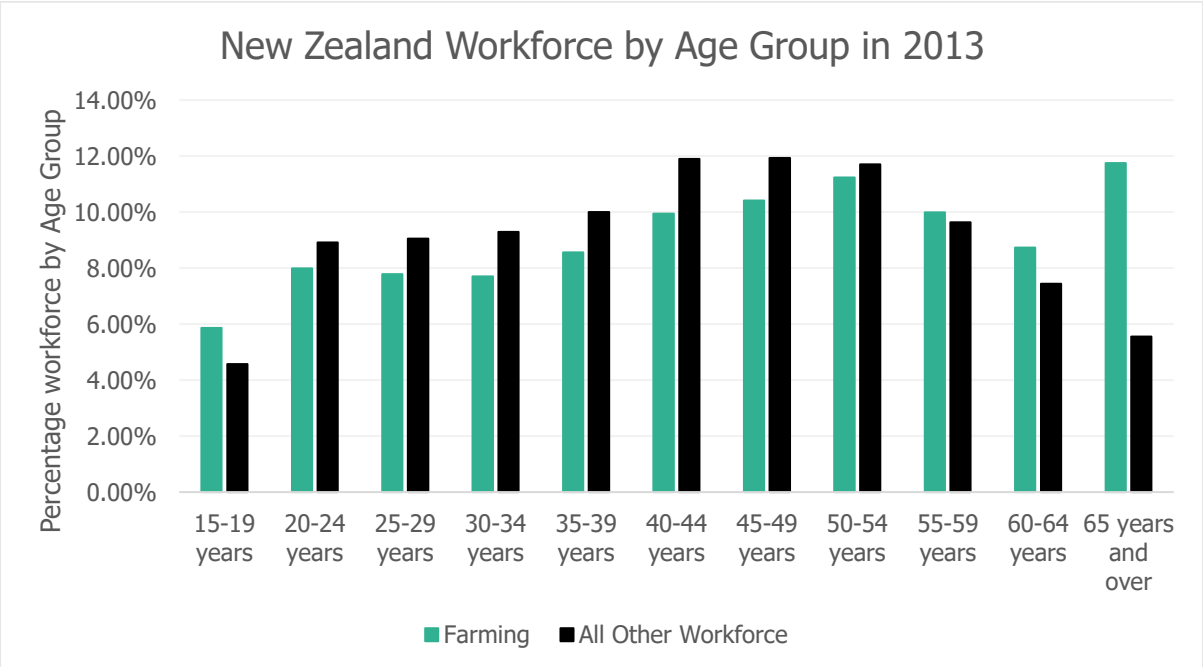


Figure 4.9 Workforce by age group in 2013 (Household Labour Force Survey, 2013c) (Rural workforce includes farmers, farm managers, skilled animal and horticultural workers as well as farm, forestry and garden workers)

The rural workforce has also shrunk significantly, in 1951, approximately 20% of the total workforce worked in agriculture, forestry and fishing, with this proportion having dropped to less than 10% by 2001 (Statistics New Zealand, 2004:2006; Pool, 2016). Some change has been noted in the growth of rural populations from migrant dairy farm workers. Dairy farming is more labour intensive than sheep and beef farming, and in many places this labour demand has been met through the employment of international migrant workers. Between 2003 and 2007, 7,000 migrant workers were granted visas to work on New Zealand dairy farms, the majority of these were to Filipino migrants followed by South Africa, Fiji, Brazil, Chile and India (Rawlinson et al., 2013). This growth is evident in Figure 4.10, which shows the workforce who identify as Asian in the Agriculture, Forestry and Fishing industries between 2006 and 2013. The Southland region has seen strong growth in this population by over 600%, potentially related to an intensification of dairy farming. This is also evident in Figures 4.11 and 4.12, where Southland and Christchurch show an increase in the proportion of the agricultural workforce who identify as Asian. This could also be responsible for altering age structures in the rural workforce.

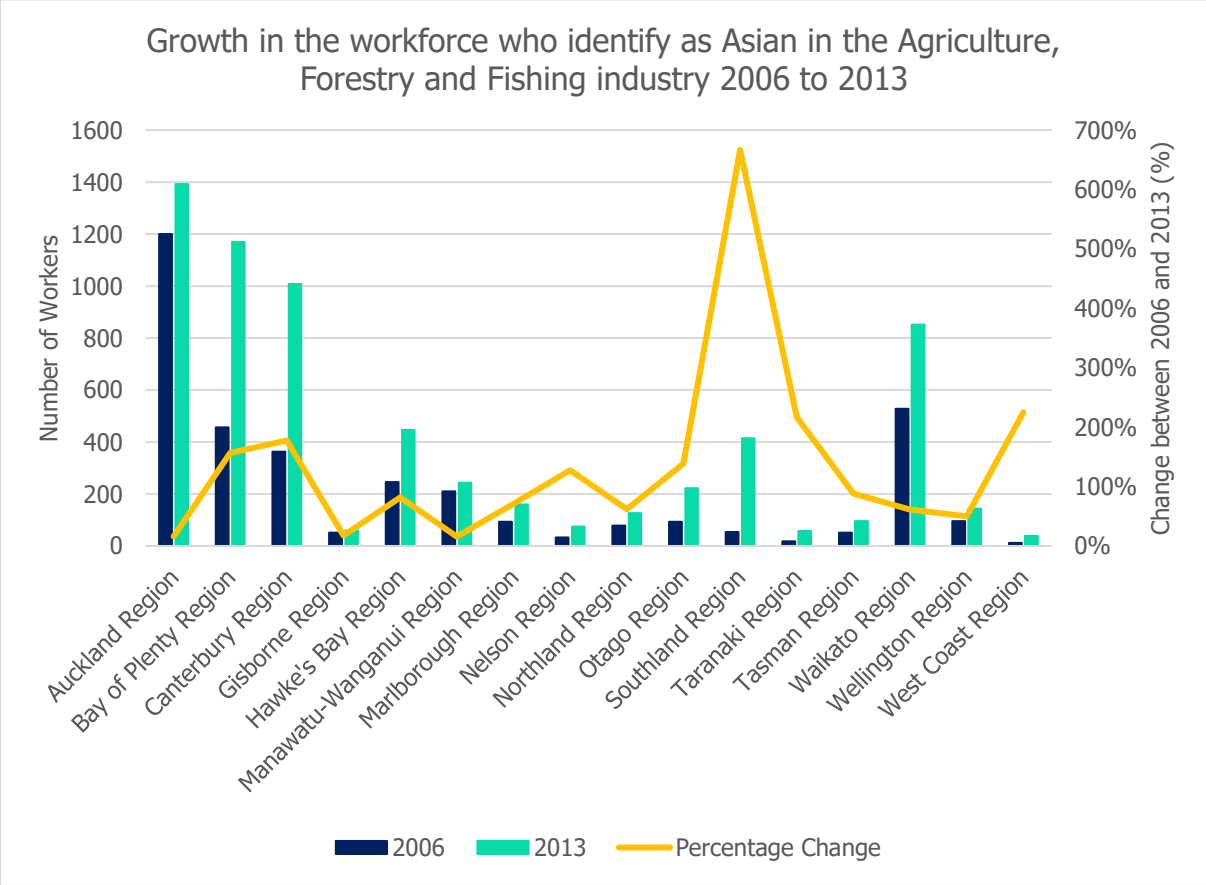


Figure 4.10 Growth in the workforce who identify as Asian in the Agriculture, Forestry and Fishing Industry (Industry (ANZSIC06 division) and ethnic group (grouped total responses), for the employed census usually resident population count aged 15 years and over, 2006 and 2013 Censuses)

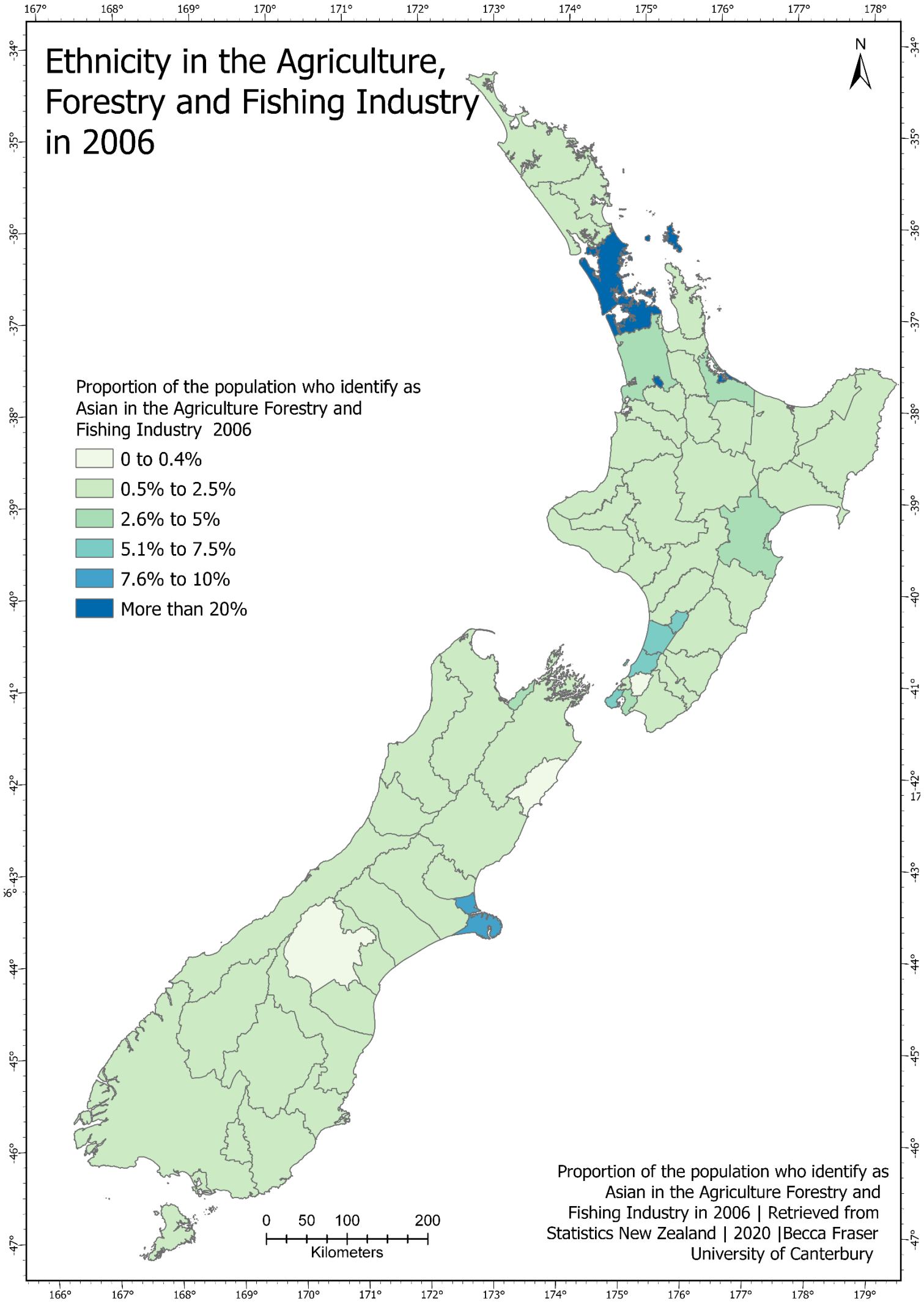


Figure 4.11 Growth in the workforce who identify as Asian in the Agriculture, Forestry and Fishing Industry (Industry (ANZSIC06 division) and ethnic group (grouped total responses), for the employed census usually resident population count aged 15 years and over, 2006 and 2013 Censuses)

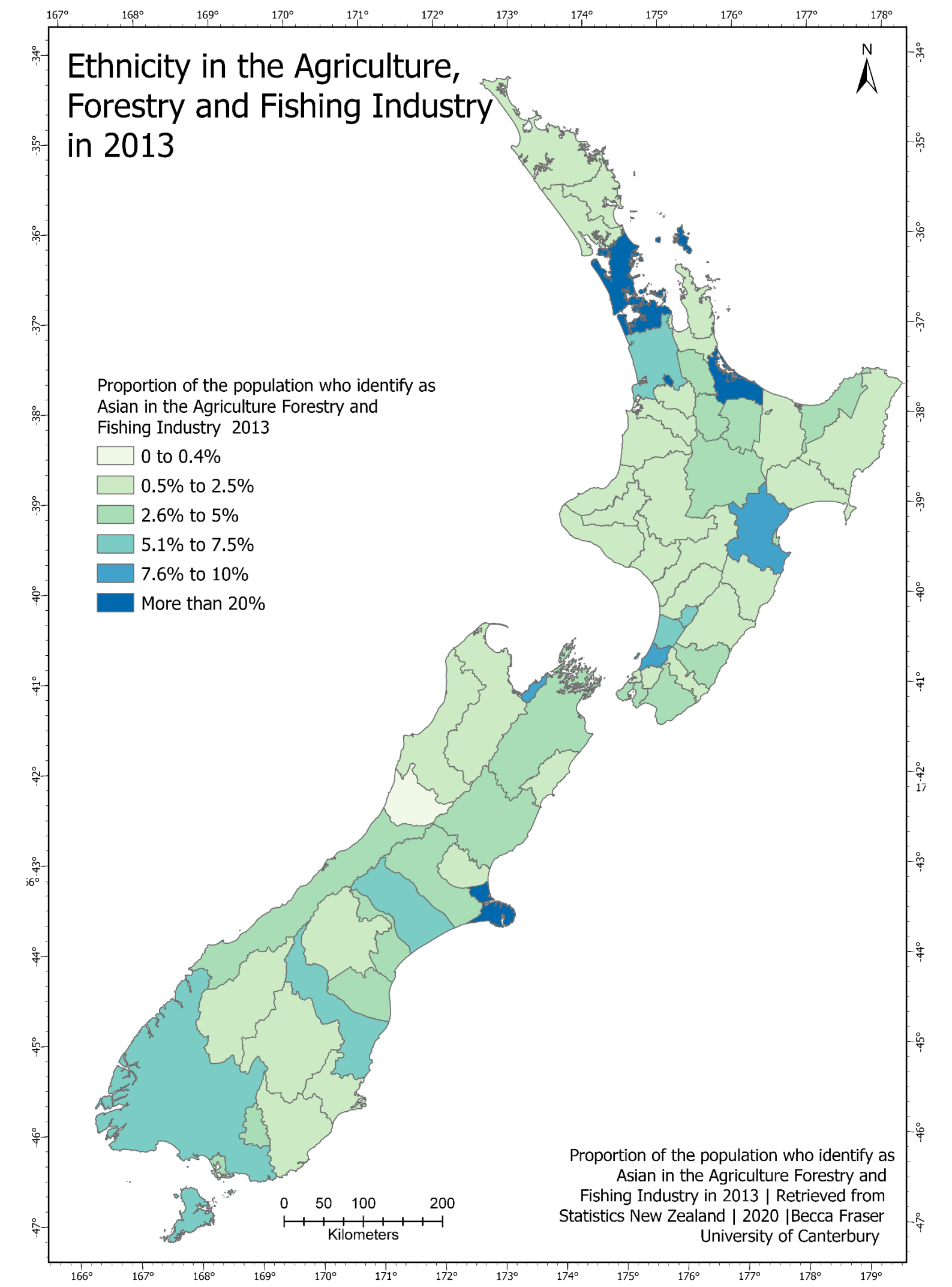


Figure 4.12 Growth in the workforce who identify as Asian in the Agriculture, Forestry and Fishing Industry (Industry (ANZSIC06 division) and ethnic group (grouped total responses), for the employed census usually resident population count aged 15 years and over, 2006 and 2013 Censuses)

4.2.4 Lifestyle Blocks

Another indicator of change in rural New Zealand is growth in rural areas with high urban influence. Sometimes termed peri-urban, or lifestyle block areas, they are typically defined by low population density, smallholdings, and a large proportion who commute to an urban centre for employment. Statistics New Zealand identified growth in these areas as the single greatest change to affect rural New Zealand in the 30 years up until 2006, with higher levels of urban influence in rural areas generally associated with higher levels of population growth and median incomes (see Figure 4.6) (Statistics New Zealand, 2009). Identifying this trend is key, as Scott et al. (2000) state, rural policies commonly equate the needs of rural communities with the needs of the agricultural sector, which may not reflect the diverse nature of rural New Zealand. Reasons for the growth of the lifestyle block population could be due to retirement, holiday home owners and lifestyle migrants (Hall, 2006). The growth of this population can be hard to capture, Figure 4.13 displays the proportion of the New Zealand population living in non-urban areas, which climbed to 14% in 2014, while the number of farm holdings showed a steady decline from over 70,000 in 2002 to 56,000 in 2014. This may suggest that the composition of the rural population could be changing, potentially from agriculturally dominant, to a more diverse mix of community members including lifestyle block owners.

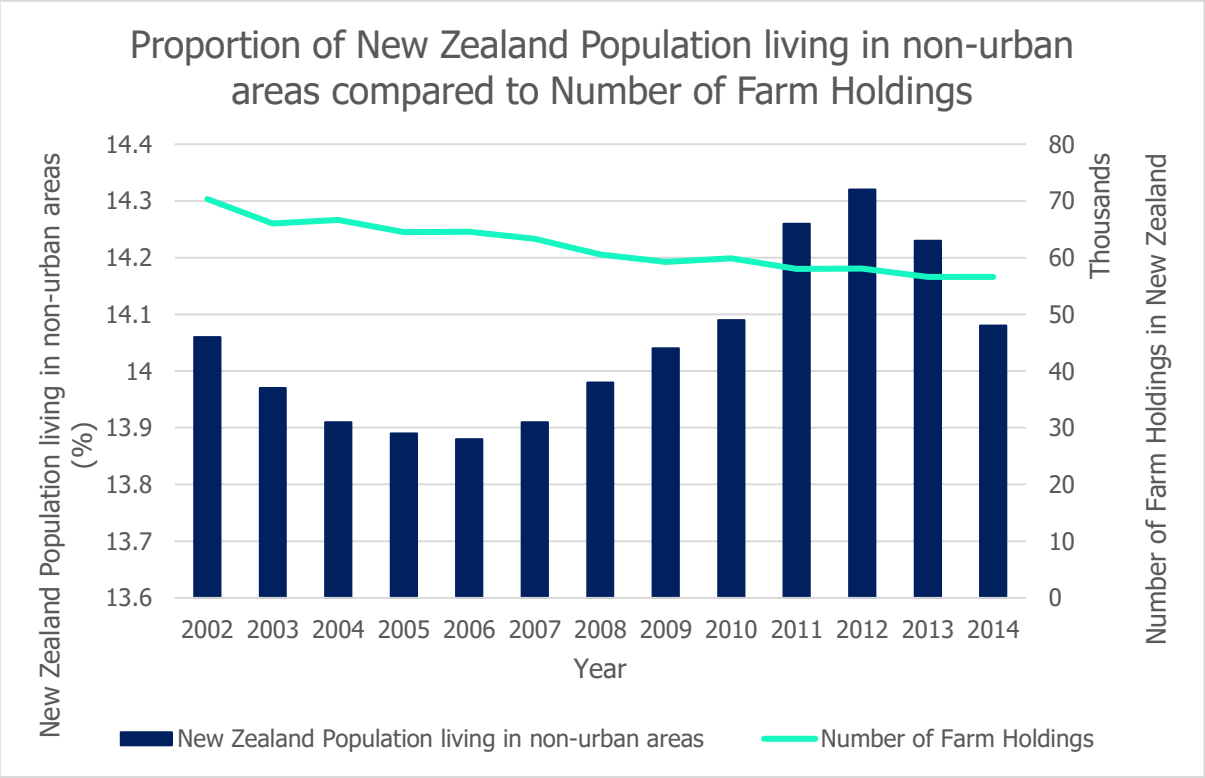


Figure 4.13 Proportion of the population living in non-urban areas compared to the number of farm holdings (Statistics New Zealand, 2017b)

The Ministry for Primary Industries (MPI) estimates the number of lifestyle blocks to have grown from around 60,000 (size between 0.4- 30ha) in 2004 to 140,000 by 2015 (2018). Shortages in urban housing supply, subdivision by farmers and a growing demand for a more rural lifestyle continues to drive demand (Lillis, Fairweather & Sanson, 2005). MPI notes that while in previous years, retired farmers tended to be the main purchasers, there is an increasing mix of baby boomers and young families moving toward the semi-rural lifestyle (2018). Figure 4.14 demonstrates the growth of these age groups in rural areas with high urban influence, the greatest growth can be seen in the 40-65 year age group, which saw 35% growth from 1996 to 2006.

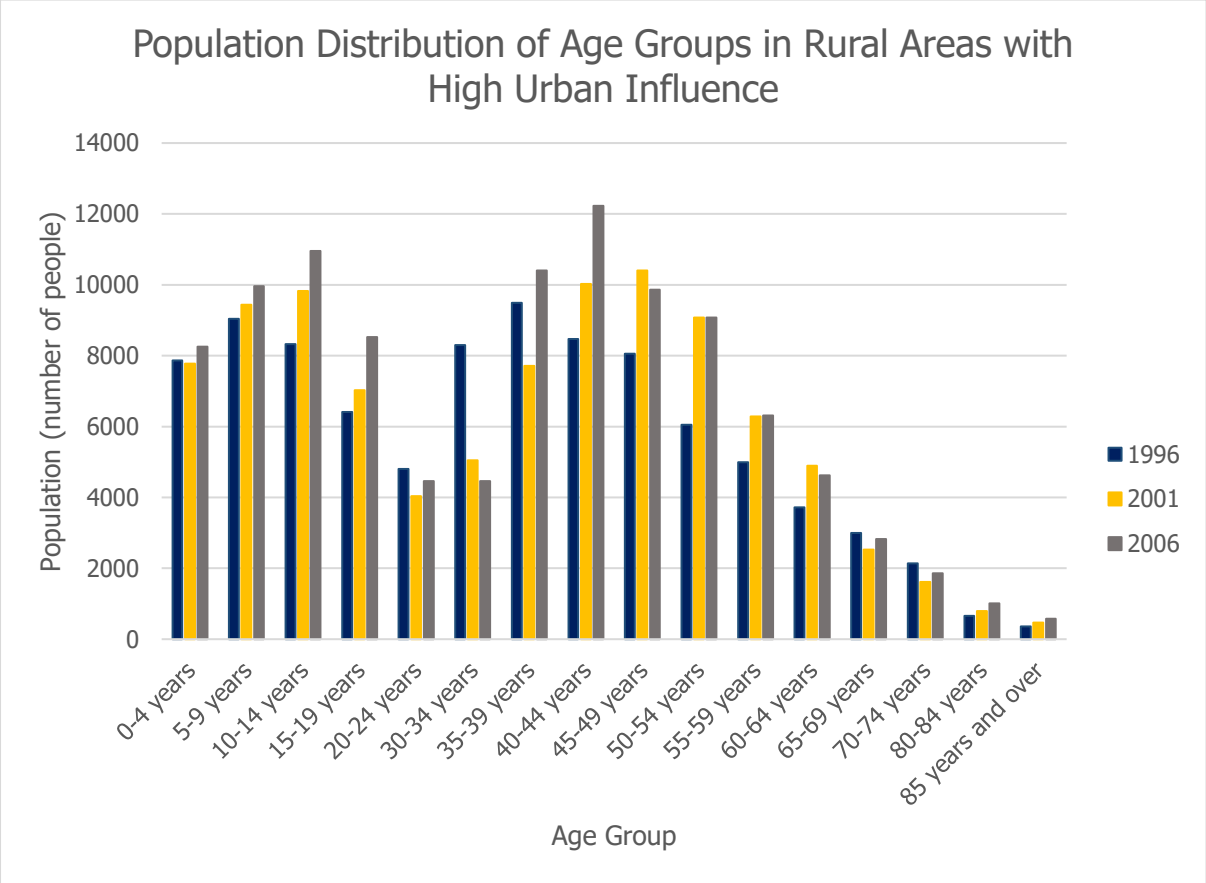


Figure 4.14 Statistics New Zealand "Population Mobility of Urban/Rural Profile Areas', 2009

An analysis of lifestyle block data from Agribase (2018) shows that lifestyle blocks tend to be more densely concentrated on the outskirts of urban centres and towns (Figure 4.15). This could be due to amenity value of these areas, with access to urban centres, quality services and reasonable costs of living (Hall, 2006). This could also reflect retirement migration patterns (Hall, 2006).

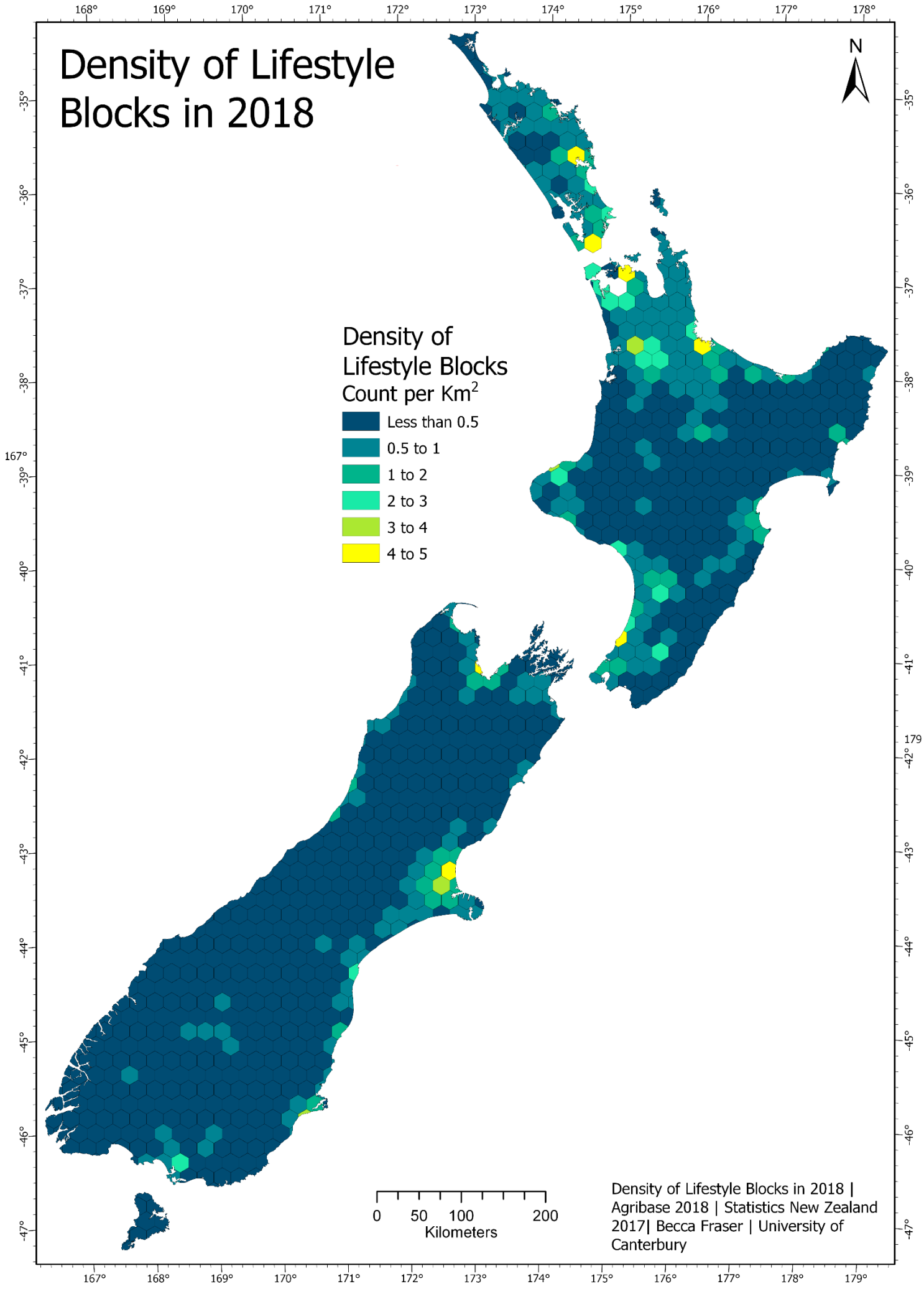


Figure 4.15 Lifestyle Blocks in New Zealand (Agribase, 2018)

4.2.5 Community Services

One of the criteria for defining rural by Statistics New Zealand is the presence of a community building, such as a church, school or store (Statistics New Zealand, 2017). However a move towards neo-liberal reform has challenged the availability of some of these services in rural areas. The State Owned Enterprises Act of 1986 heralded major change in New Zealand's state sector, a number of government departments became more commercially oriented, with a push for greater efficiency and profitability (Goldfinch, 1998). Many small communities, especially rural ones, bore the brunt of this rationalisation in services. The transfer of many services to the private sector meant that those that were inefficient or uneconomic were shut down or dramatically reduced (Woods, 2006). Additionally, the principle of 'standard pricing' for rural services also gradually eroded, with pricing now reflecting geographical variations in cost. These changes can more dramatically impact rural areas where smaller populations that are sparsely populated become disadvantaged.

Rural service provision is often interchangeably equated with the 'rural way' of life, with services as the glue that holds the community together (Woods, 2006). Conversely, the closure or reduction of rural services is often seen as a threat to the 'rural way' of life. In many ways rural services have not only functional properties but strong symbolic meanings as core components of the rural community. Rurality is often defined by the presence of these services, and so the loss of services like the bar, post office or local store are often seen as the loss of community.

Examples of the closure of rural facing services include banking, post offices, schools and medical centres. The first Post Office in New Zealand opened in 1840 in Kororareka – Russell and by 1880, 850 post offices were scattered around the country (New Zealand Post, 2017). At the beginning of the 20th century New Zealand Post was a government department with over 1700 branches, which played a key role in rural communities. Services provided included traditional mail and telecommunication services, registration of births, marriages, deaths and cars, television and fishing licence fees, vote enrolment and pension collection. Post Offices also provided weather information for the meteorological office and postmasters could even perform

marriage ceremonies. This range of services reflected the key roles of the Post Office in rural life, essentially as a government 'front office' (New Zealand Post, 2017). Like many rural services, post offices played a vital role in community life and identity.

By the 1980s, policy decisions led to the reframing of the Postal Service as separate State-owned Enterprises, with the separation of telecommunications and banking services and the closure of 432 post offices in 1988 (a third of its network, mostly in small communities), as well as the introduction of differential charging to rural areas (Woods, 2006). By 2018, 801 of New Zealand Post's 880 stores were franchised and based within other retail services. Spatial data for this was requested from New Zealand Post, however closure data is held by Archives New Zealand, non-digitized and behind a paywall, so was unable to be collated in the timeframe of this research.

A similar story can be seen with rural banking services. Matthews (2000) notes that during the 1990s, over 40% of bank branches were closed, with small rural areas the most heavily impacted. Some of these closures were mergers, however a number of them were closures in townships where the cost of the bank branch exceeded the population base. As a result, a number of rural towns were left with no bank representation. Ongoing technological change such as access to broadband and telecommunications has continued to change the nature of banking services in many rural towns. Due to the commercially sensitive nature of bank branch closures, spatial data was unable to be collated for this research.

4.2.6 Schools

In many rural communities, school buildings were one of the first community buildings to be built, and have been maintained for generations by voluntary resources and labour as a community resource (Witten et al., 2003). Like many community buildings, rural schools perform services beyond their basic functions, and are often the focal point for community life, vital in terms of community identity and memory (Kearns et al., 2010). Kearns et al. (2010) argue that a rural settlement is just that, a cluster of residents and enterprises but one of the components of a rural community is a school.

Joseph et al. (2001, p.3), note that following the structural changes of the 1980s, rural schools were one of the *"last bastions of public investment in rural communities"* with considerable significance as a focus of community life (Scott et al., 2000).

Throughout the 1990's, an extended period of government driven rationalisation changed the role of schools in rural community life (Witten et al. 2003). From the 1990's until 2005, a series of Ministry of Education Network Reviews resulted in the closure of 141 rural schools (see Figure 4.16 and 4.17). The Network Review process in many places was seen as an assault on rural New Zealand, by a bureaucratic process that had little understanding of the role schools play in rural life. It was halted in 2005 in response to growing opposition in communities (Kearns et al. 2009). Of all schools closed between 1999 and 2019, 57% were rural schools (Figure 4.17 and 4.18) (Education Counts, 2019). Figure 4.18 displays the spatial impact of this change on rural New Zealand.

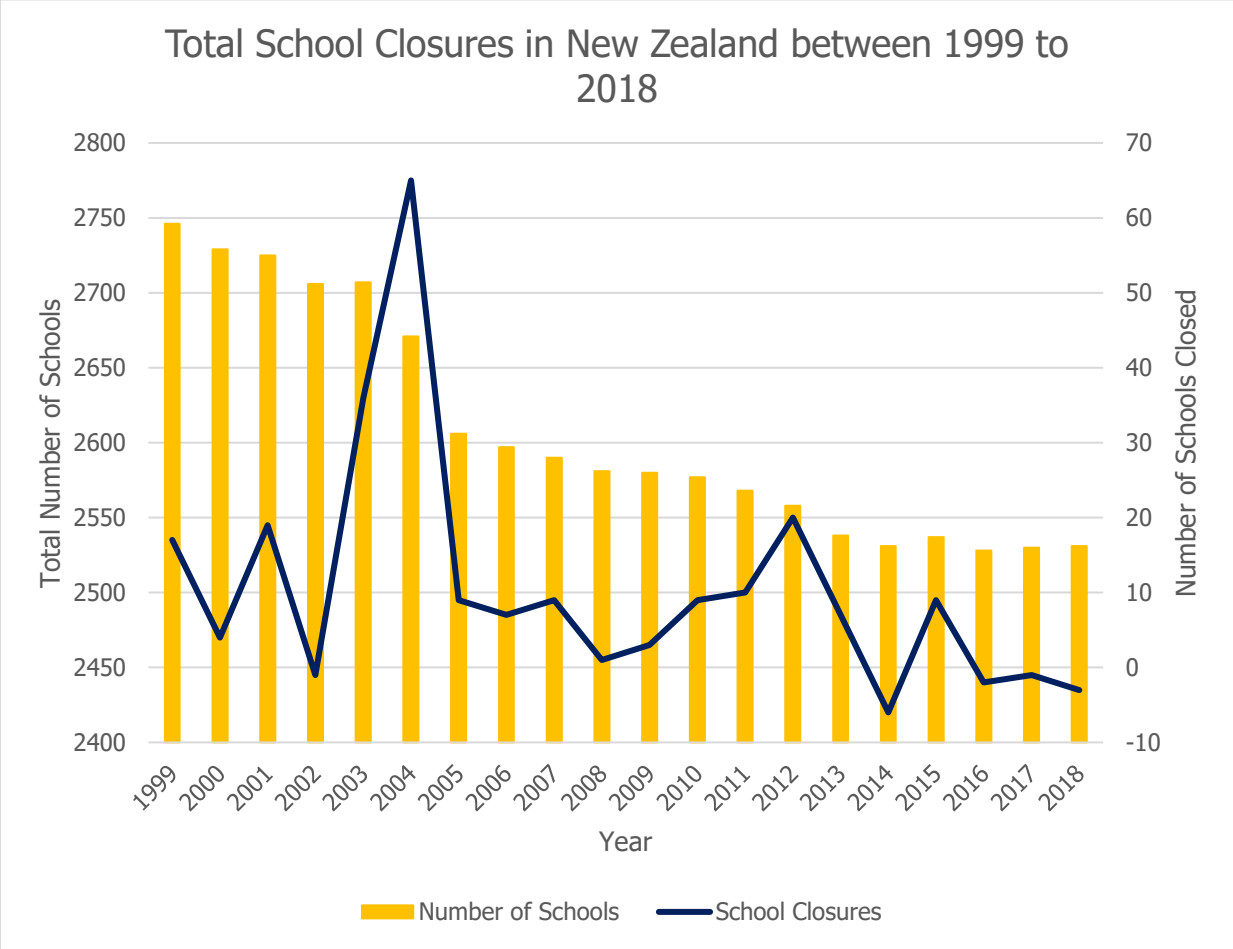


Figure 4.16 Total School Closures in New Zealand between 1999 and 2018 (Education Counts, 2019)

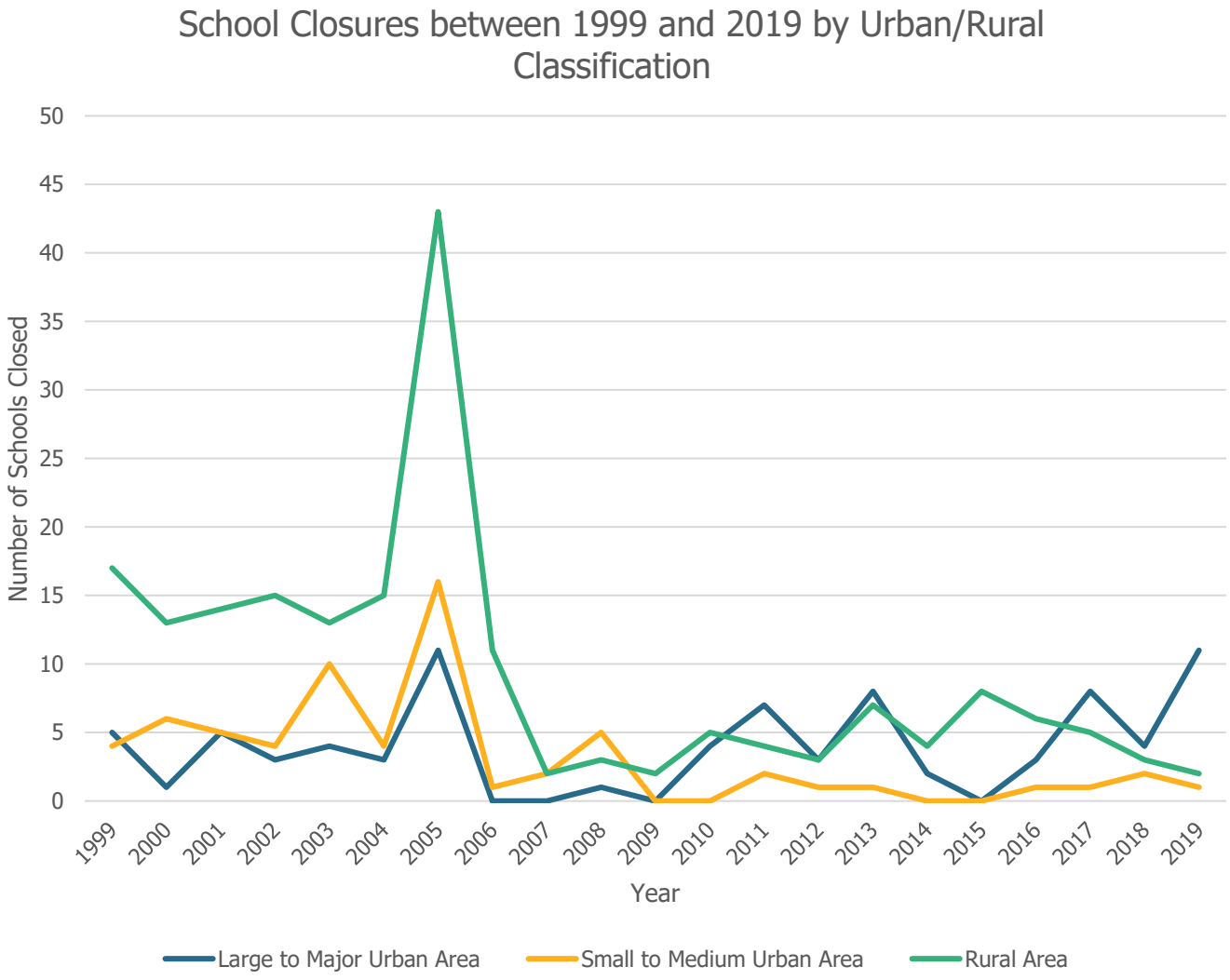


Figure 4.17 School Closures between 1999 and 2019 (Education Counts, 2019)

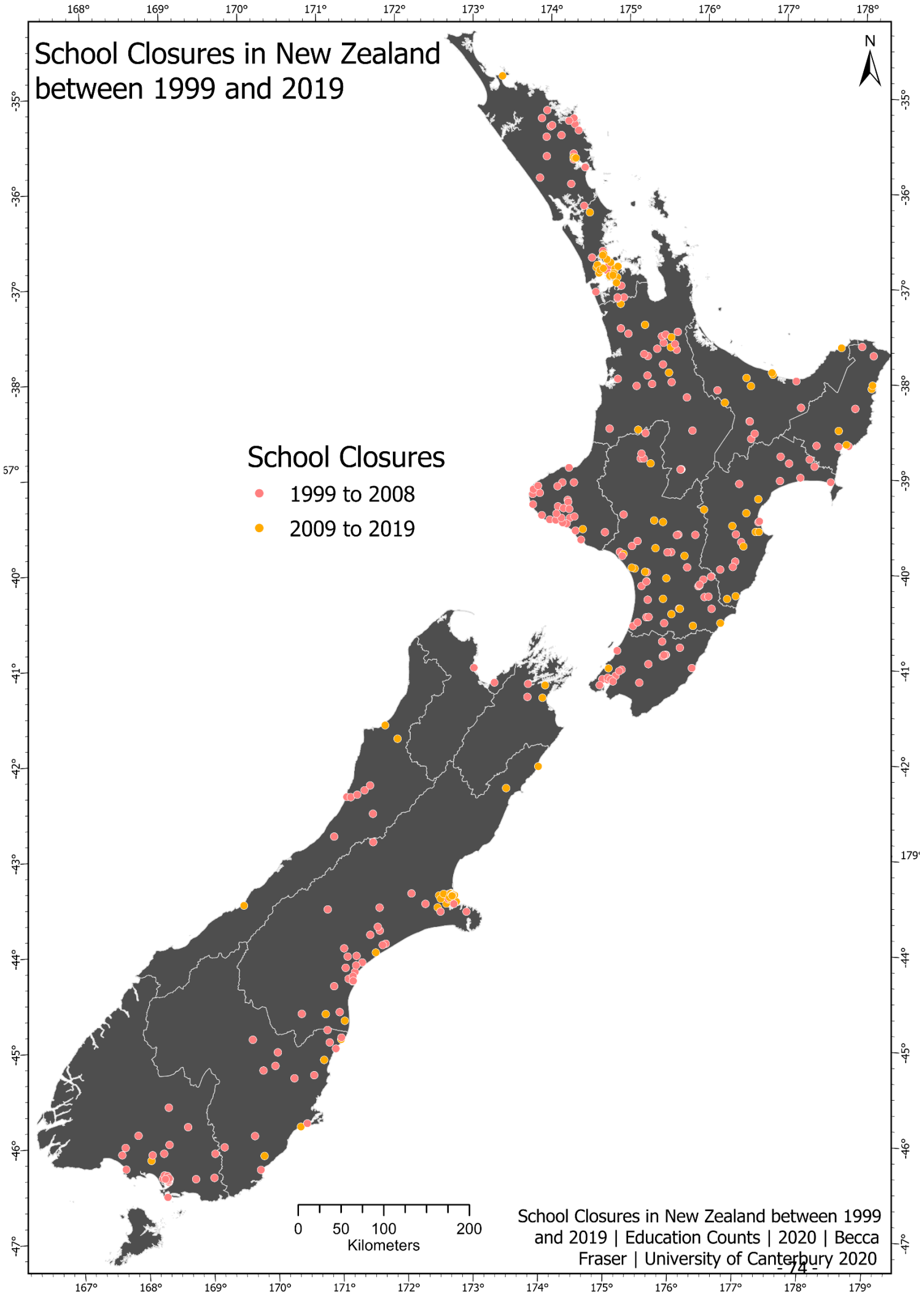


Figure 4.18 School Closures between 1999 and 2019 (Education Counts, 2019)

4.2.7 Healthcare

This section considers both access to general practice (GPs) and rural hospitals, in part because these services are often administered by the same people in remote rural areas. In rural New Zealand, the first hospitals were set up shortly after European immigrant settlement, primarily in centres such as Auckland and Wellington. By the turn of the 20th century a range of medical service providers were operating, including mental hospitals, sanatoriums and maternity homes, many based within rural centres (Bryder, 2011; Fraser, 2006; Swarbrick, 2008). Many hospital services were managed regionally and by local communities. From the 1970s many maternity hospitals were closed. Major reforms throughout the 1990s led to the closure/downsizing of many rural medical centres. Figure 4.19 indicates that there has been a decline in the number of hospital beds (per 1,000 people) between 1960 and 2013, from 11.7 per 1000 people, to 2.30. This is spatially presented in Figures 4.20 and 4.21 (Bryder, 2011).

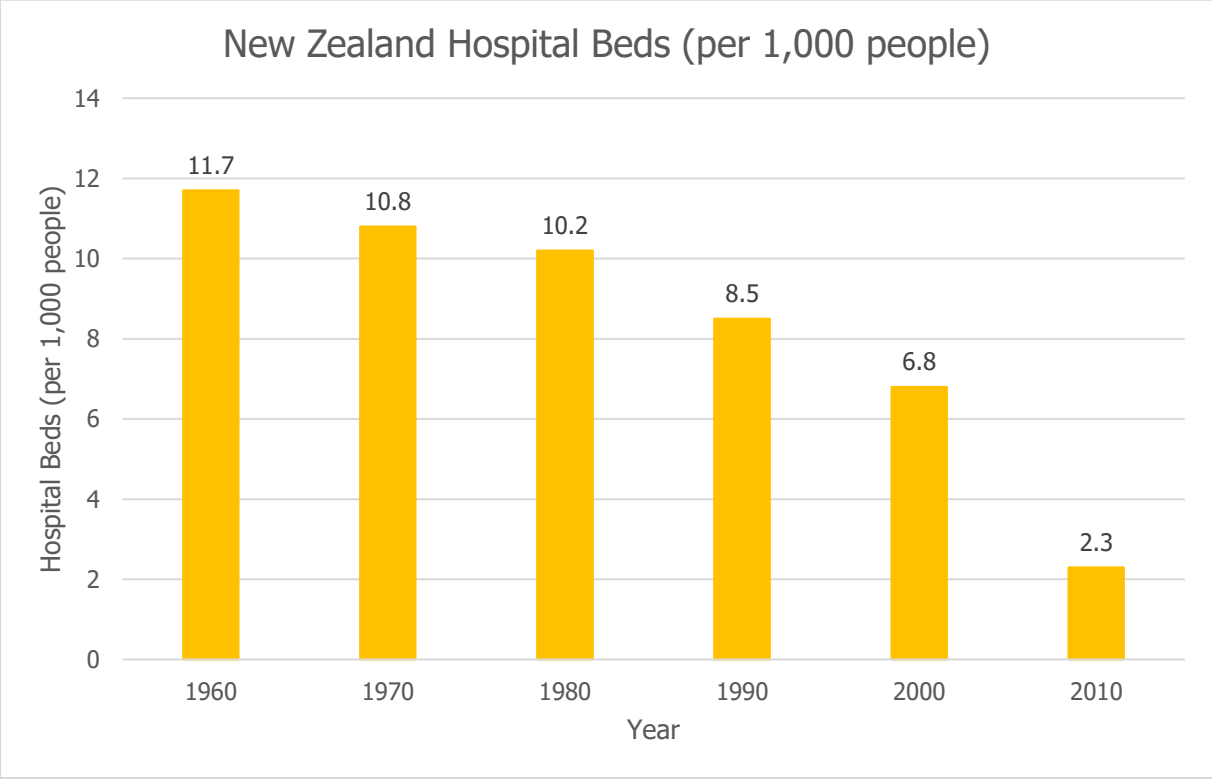


Figure 4.19 New Zealand Hospital Beds per 1000 people (World Bank, 2020) (Includes inpatient beds in private, general, public, specialized hospitals and rehabilitation centres)

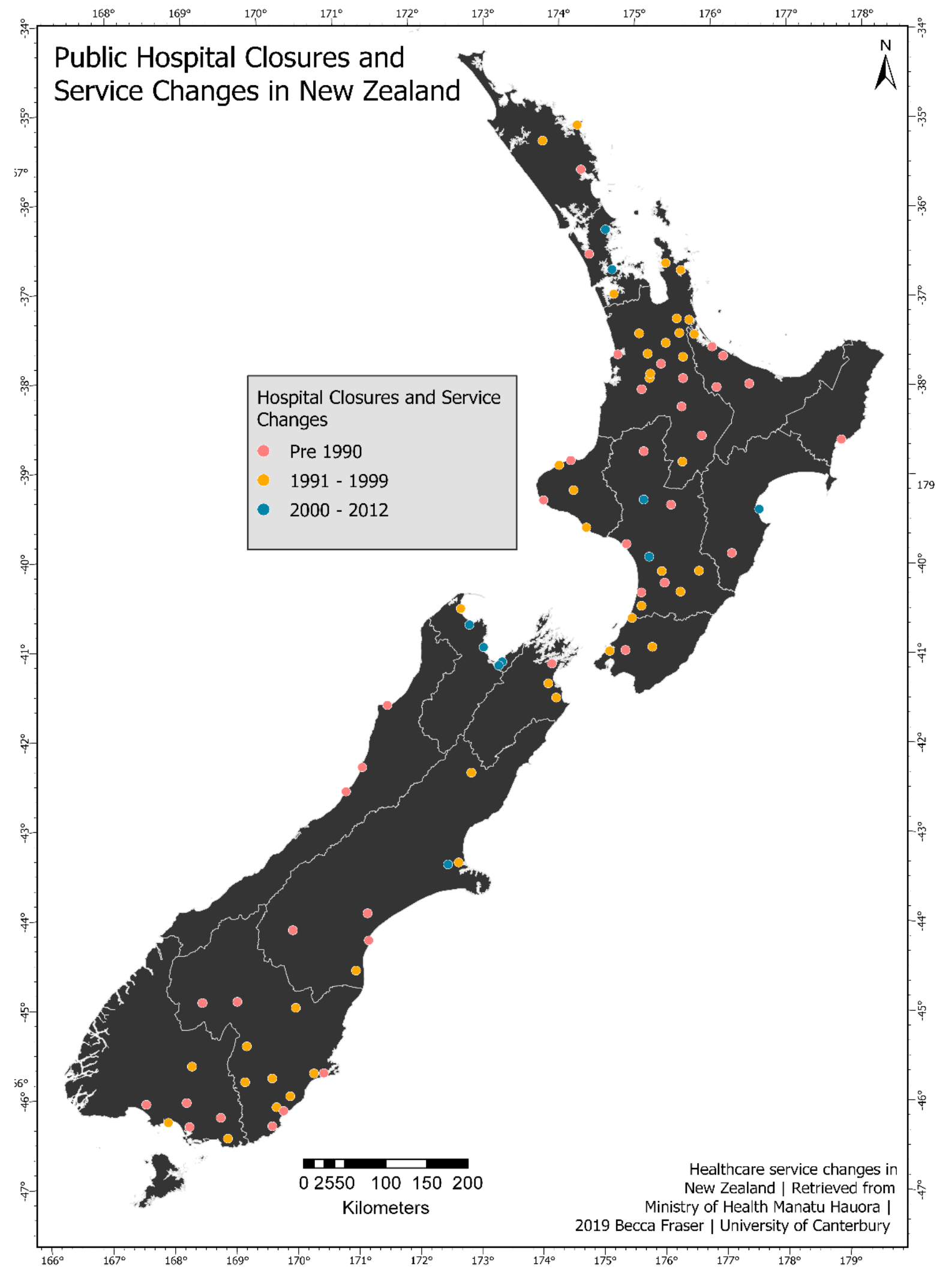


Figure 4.20 Public Hospital Closures and Service Changes in New Zealand (Ministry of Health, 2019)

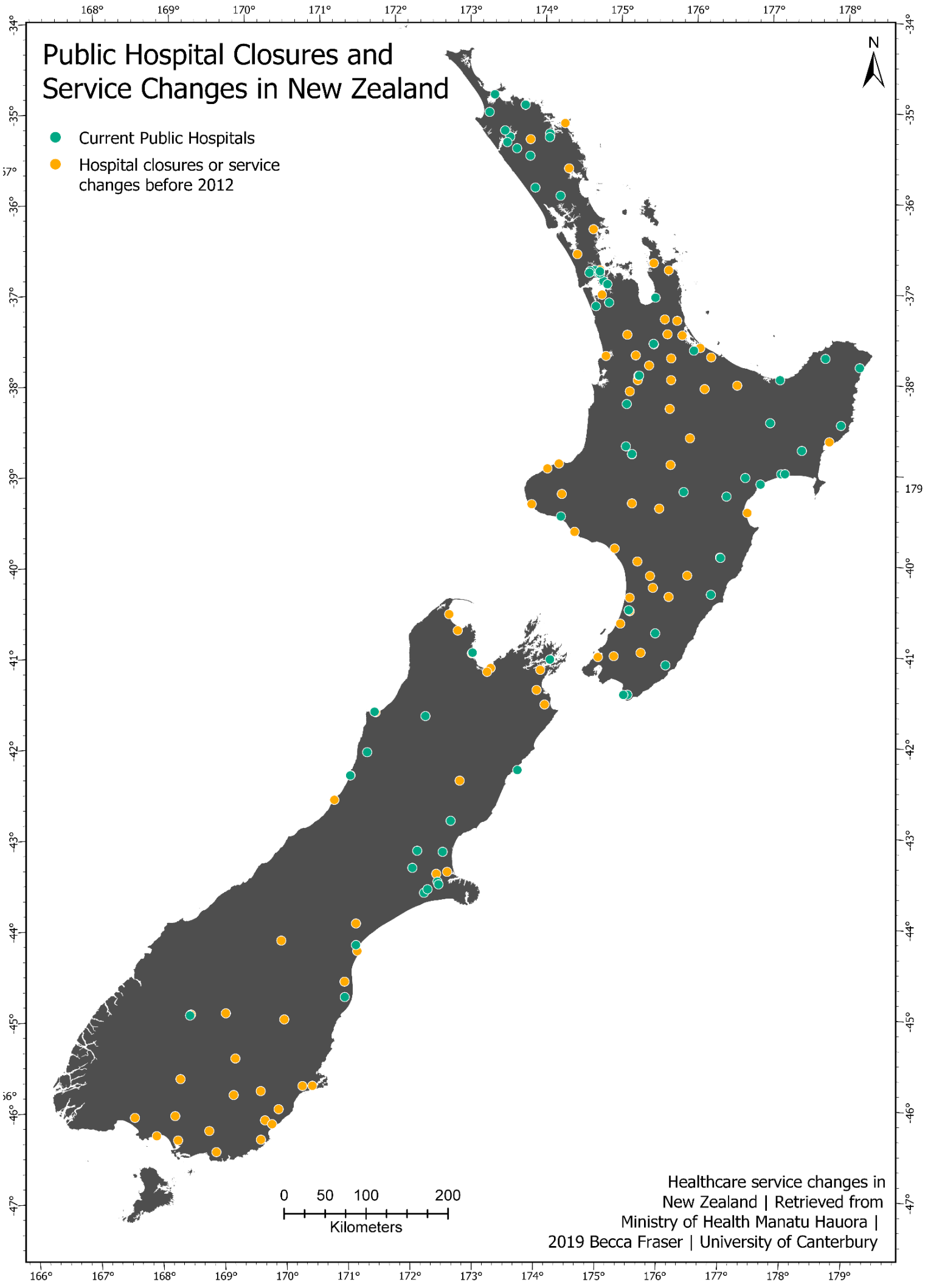


Figure 4.21 Current and Closed Public Hospitals in New Zealand (Ministry of Health, 2018)

4.2.8 Limitations

This section outlines limitations of the results presented in section 5.3.1. While at the regional level, population growth in places appears to have occurred, at the sub regional level this is not always the case, as significant sub regional population loss (such as from rural areas) can be masked by the growth of key centres in those regions (Nel, 2015). Capturing specific rural population change is difficult as there are many different definitions of 'rural', census data also has limitations due to changing data collection methodologies over time. Until 1945, separate censuses took place for the non-Maori and Maori population, so overall population numbers may be undercounted (RCG, 2018). Additionally, while with few exceptions, censuses have been carried out every five years since 1881; notable cancellations and postponements of the census include the Great Depression, World Wars One and Two, and the Canterbury Earthquake Sequence (2011 census postponed to 2013) (RCG, 2018). Further limitations are outlined in Appendix A.3.

Demographic change is highly contextual, and it is difficult to make national level generalisations about rural demographic change, so while large scale changes have been considered, the actual change at the community level could be different. The subjectivity with which urban and rural are defined by Statistics New Zealand also creates complications when analysing semi urban populations or areas of low population density (RCG, 2018). It is also important to note that the farming workforce does not neccesarily represent all of the rural workforce and does not include those who work in the rural service or tourism industry.

Data in the rural service datasets had to be individually geolocated, in some cases, it was very difficult to find exact address points. Therefore in some cases school points have been placed on the correct road, within the vicinity of their former location (where possible exact locations have been used). The healthcare dataset does not include private hospitals, and does not indicate where closed hospitals became rest homes or other community buildings.

4.3 Environmental Trends

In the literature, environmental trends that indicate changing rural resilience include factors like changing climate and natural hazard impacts, as well as land use change. The literature and data reviews identified three potential datasets for changing environmental trends:

- Drought
- Land Use Change
- Livestock Changes

4.3.1 Drought

Environmental Health Indicators New Zealand (EHINZ) identifies drought frequency and intensity as an ongoing challenge to rural communities (2018). They also note that drought can impact communities differently due to external factors such as socioeconomic deprivation and those who are employed in water dependent industries like farming and forestry (EHINZ, 2018). Much of New Zealand's pastoral farming, such as dairy and livestock, are predominantly supplied by rain fed systems (Cradock-Henry et al., 2019). However many researchers note, that due to the complex nature of drought, adequately characterizing the impacts on communities can be difficult (Pourzand, Noy & Saglam, 2019; Birthal et al., 2015).

MPI has a three stage framework for declaring an adverse event, this can include events like flood, fires, earthquakes and drought. Several factors determine the scale of declaration including magnitude of the event, capacity of the community to cope and the preparation and recovery options available. To declare a drought event factors including extent, level of impact and things like access to supplementary feed determine the classification as an either local, medium and large scale adverse event (Melyukina, 2011) The scale of declaration determines funding and assistance for affected communities and includes things livestock feed support, psychosocial support and professional recovery advice for farmers.

New Zealand has experienced several major droughts in the last decade. From 2007 until 2016 (Figure 4.22), at least 50% of districts in New Zealand experienced at least

one severe drought (Pourzand et al., 2019). In a farm level analysis of the drought impacts, Pourzand et al. (2019) found that on average, dairy farms are less adversely affected by drought than sheep and beef farming (potentially due to increasing milk prices compensating for lower milk production) in the short term, but that all droughts have a significant negative impact on long term farm revenue and profit. This has a cascading effect on services in rural communities and land maintenance (Smith et al., 2012).

In 2013, a drought affected the whole of the North Island and the West Coast of the South Island *(Figure 4.22).* The Ministry for Primary Industries (MPI) estimated the impact of this on the economy as at least $1.3 billion, causing the GDP to drop by an estimated 0.6% (Pourzand et al., 2019; Kamber, McDonald & Price, 2013). An earlier major drought in 2007-2008 cost the New Zealand economy $2.8 billion. This underscores how important the rural sector is to New Zealand's economy, and the importance of understanding drought impacts (Carter, 2013).

While different scales of drought are evident in Figure 4.22, different regions can experience potentially uneven impacts of drought on different industries and livelihoods. More detailed community level data could help researchers to better understand the long term impacts of repeated drought on community disaster resilience. Supplementary drought maps are provided in Appendix C.1.

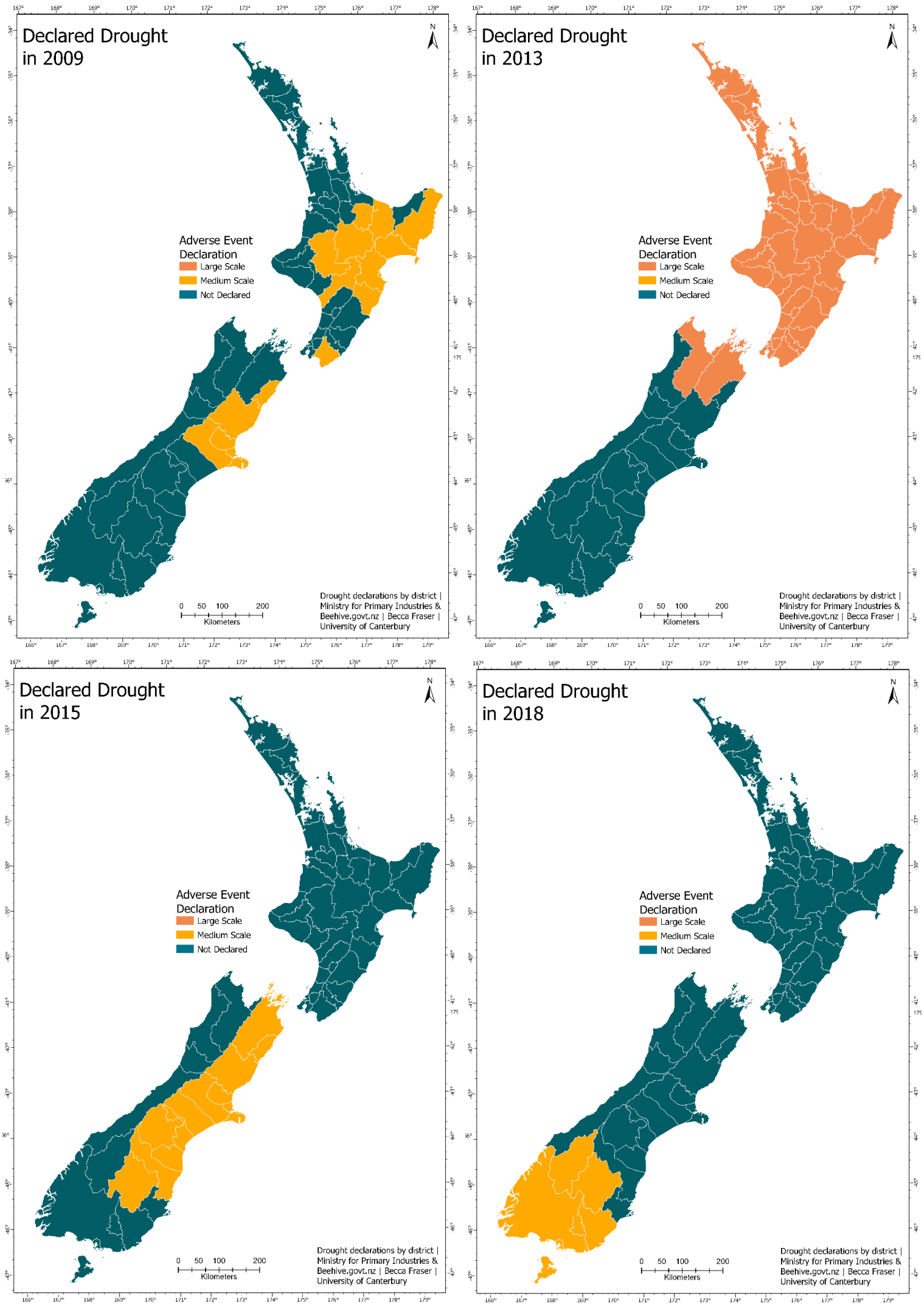


Figure 4.22 Declared Drought 2009 to 2018 (Ministry for Primary Industries, & Beehive.govt.nz 2009:2018)

4.3.2 Land Use Change

Panelli, Stollte and Bedford (2003) note that agricultural change is a recurring theme in rural studies throughout the world, particularly in response to socioeconomic change. This is reflected in the changing activities taking place in New Zealand's rural communities. Significant land use change and diversification, including into dairy farming, horticulture, forestry and viticulture has continued to drive change in the rural context (Smith et al., 2011; Spector et al., 2018).Macleod and Moller (2006) identify steady intensification and diversification of New Zealand agriculture. This indicated by increased livestock yields, fertiliser use, conversion to intensive agriculture like dairy, and diversification into different land uses such as forestry. They also identify a contraction in sheep farming, and its associated services from the early 1980s until the early 2000s. Some of the most notable land use changes include the expansion of dairy farming into previously sheep and beef dominated areas, and increase in lifestyle blocks and the subdivision of high class and coastal land. Additional changes include increased irrigation, diversification and expansion into other industries such as the wine and forestry industries (Smith & Montgomery, 2004). Changing land area by farm type indicates that there has been growth in viticulture, dairy and grain and crop farming. Sheep and all other farming types witnessed a decline in land area between 2007 and 2017 (Figure 4.23).

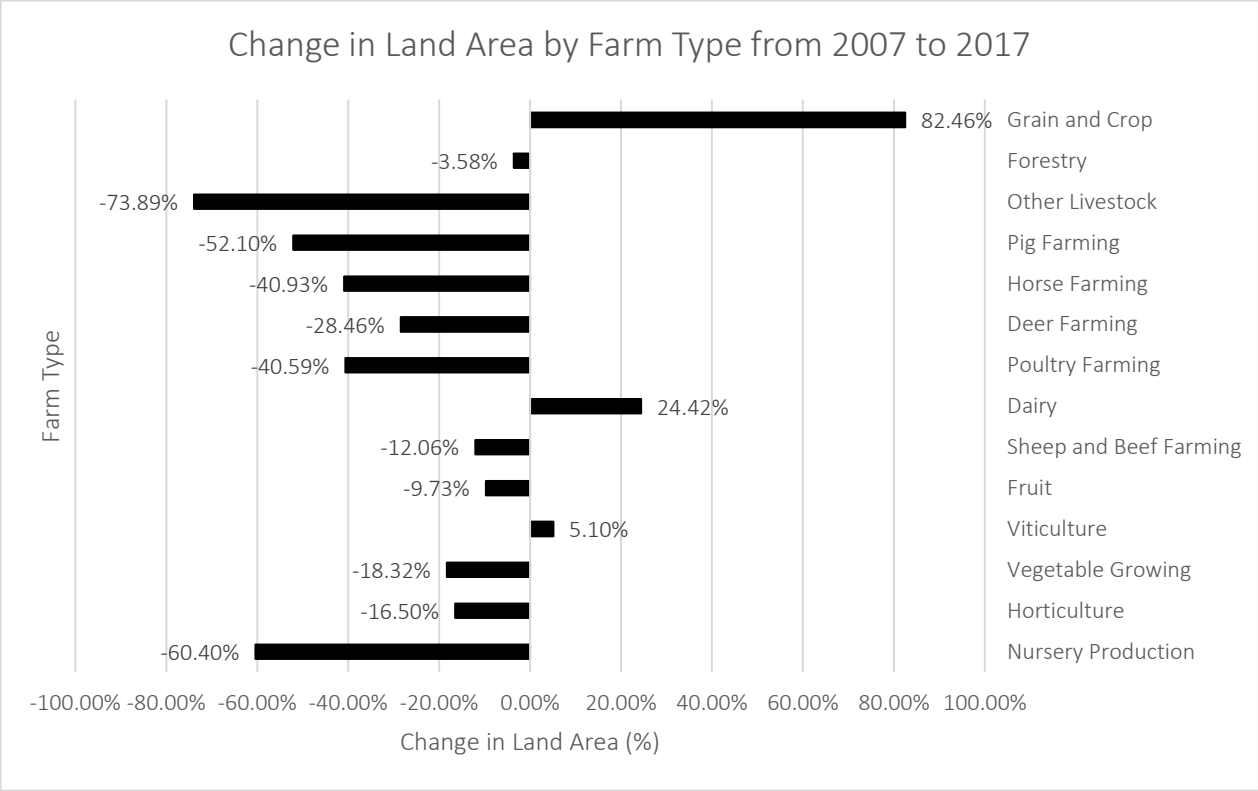


Figure 4.23 Change in Land Area by farm type from 2007 to 2017 (Agricultural Production Statistics, 2007; 2013 Farm type classification is based on the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006)

A decline in farm numbers and increase in the size of farms has been a major rural trend noted in New Zealand, Canada, US and Australia (Fairweather, 1987; Moran, 1997). In New Zealand, economic pressures in the 1970s and 1980s pushed middle sized farm holdings out in favour of larger holdings alongside a substantial increase in small lifestyle blocks (Moran, 1997; Fraser, 2006) (Figure 4.24). This change in farm sizes could also indicate changing farm types, evident in changing land use patterns seen in Figures 4.28, 4.29 and 4.31.

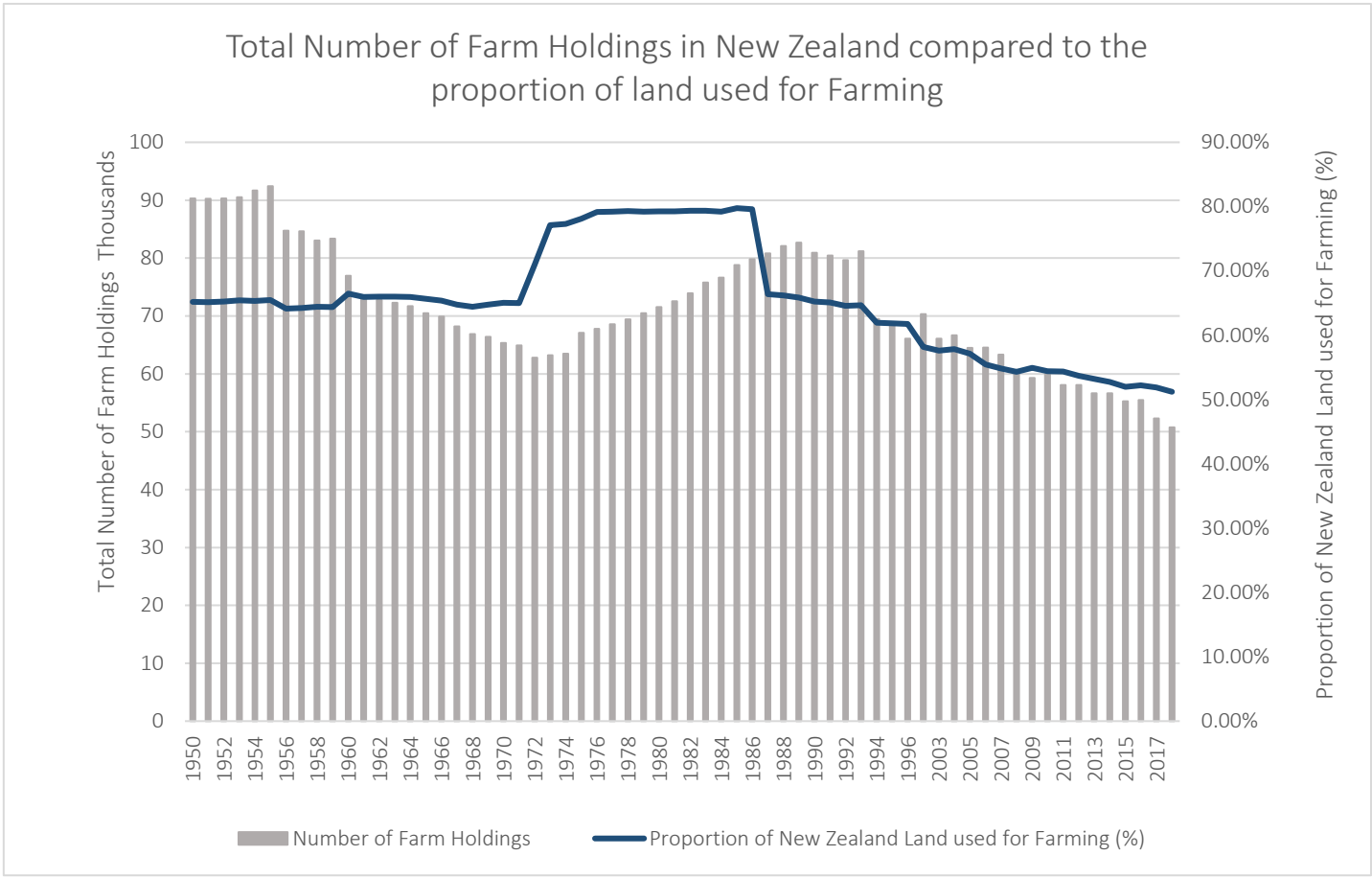


Figure 4.24 Total Number of Farm Holdings in New Zealand compared to the proportion of land used for farming (Agricultural Production Statistics, 2018)

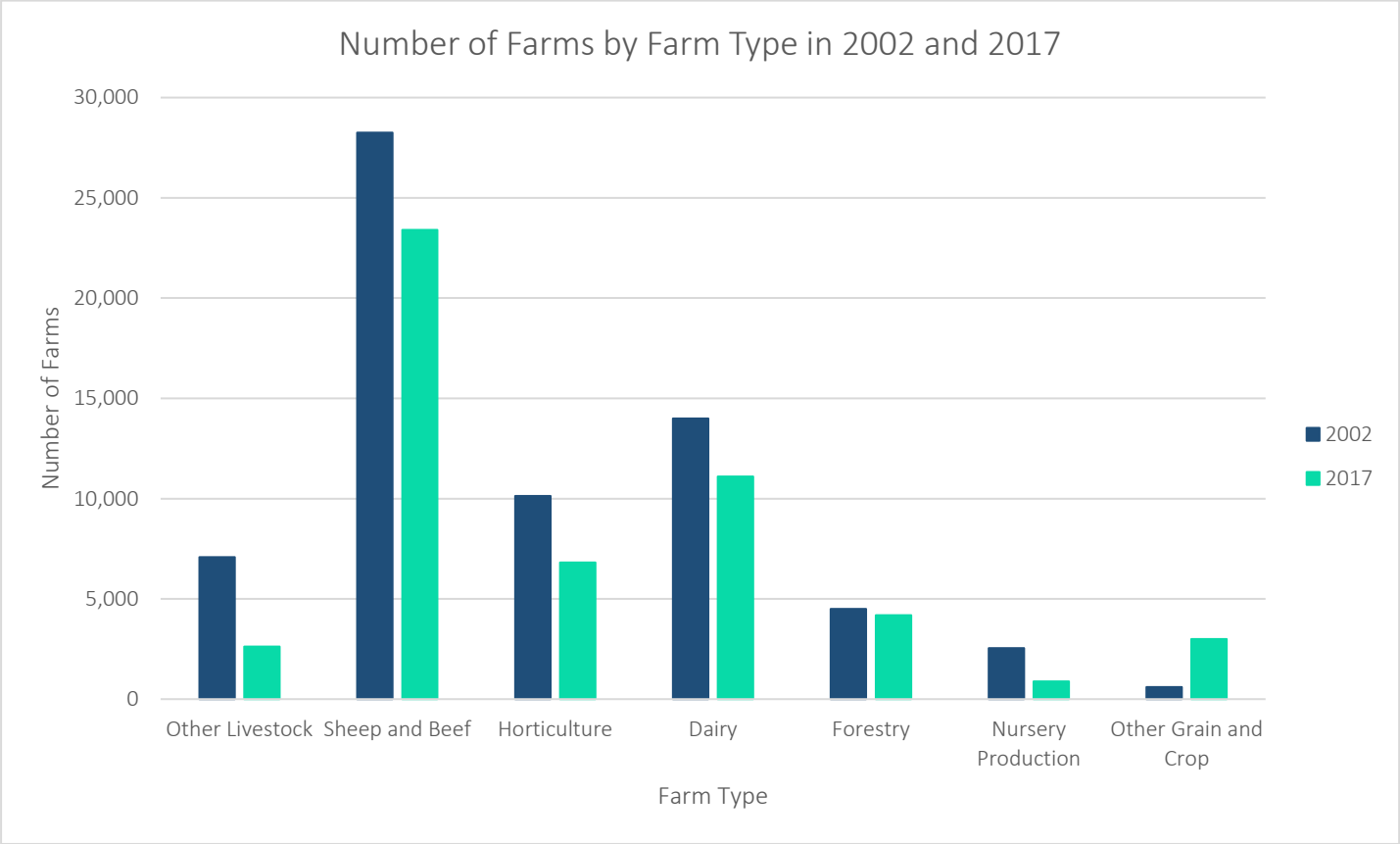


Figure 4.25 Number of Farms by Farm type from 2002 to 2017 (Statistics New Zealand Agricultural Production Statistics 2002; 2017)

From 2002 to 2017, the total number of farms decreased by 24%, the land area for these farms also decreased by 10% (Figures 4.23 to 4.25). Dairy farm land area increased by 22% indicating the size of dairy farms may be increasing. Arable crop farming increased by 2,381 suggesting diversification into other farming types (Statistics New Zealand, 2017b). Figure 4.25 indicates that there has been a general decline in all farms except grain and crop farms between 2002 and 2017. While the number of horticulture farms decreased by 3,321, the land area of horticulture increased by almost 30% suggesting a trend towards larger farm sizes (Figure 4.23).

Until the 1980s, agriculture was dominated by sheep and beef production (Evans, 2004). In 1984 it occupied 63% of New Zealand's farmed land, and contributed 36% of total exports (Pomeroy, 2015). Sheep and beef farming has seen a gradual decline. Sheep in New Zealand numbered 70 million in 1984, dropping to just under 30 million in 2015, with a similar decline evident in beef livestock numbers (Figures 4.26 and 4.27)(Pomeroy, 2015). Figure 4.28 indicates the differential regional impacts of this

change, Canterbury experienced a notable decline in sheep livestock density, and Southland experienced an increase in beef livestock intensity between 1994 and 2017.

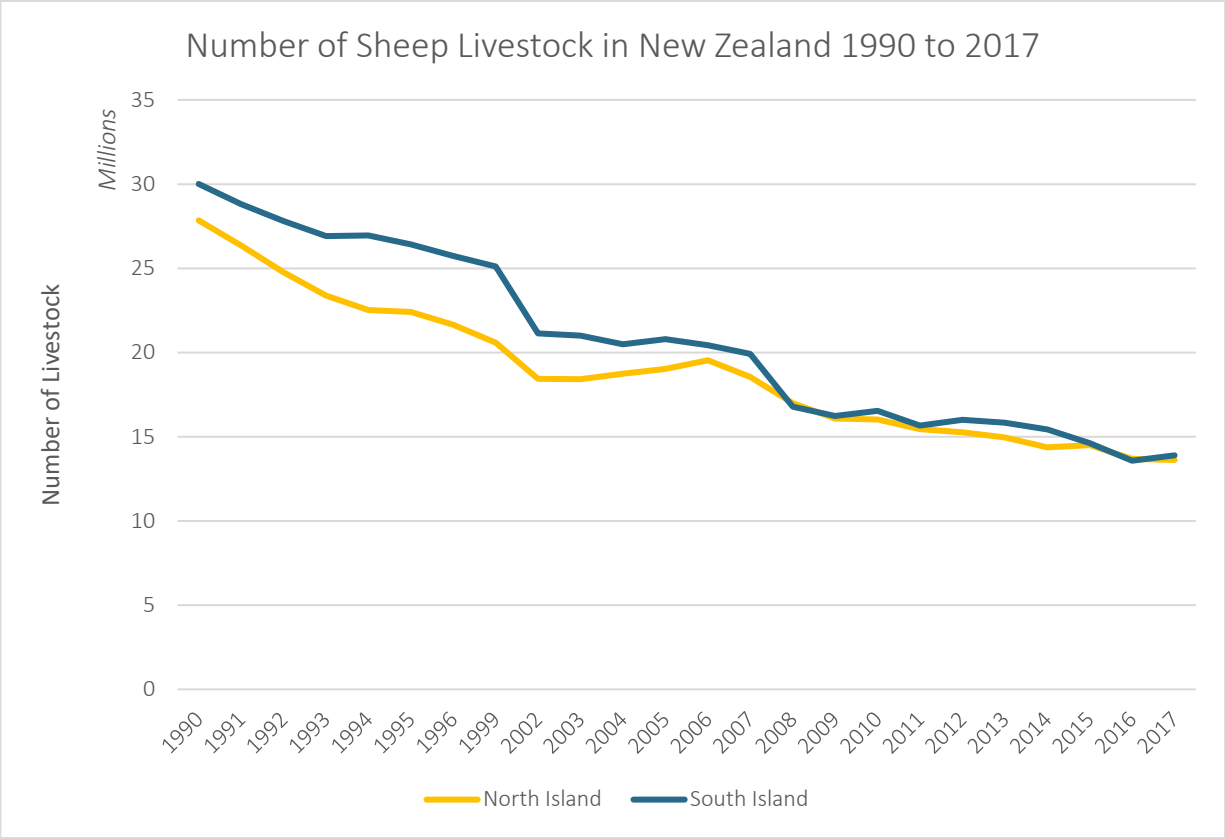


Figure 4.26 Number of Sheep Livestock in New Zealand 1990 to 2017 (Statistics New Zealand, 2018d)

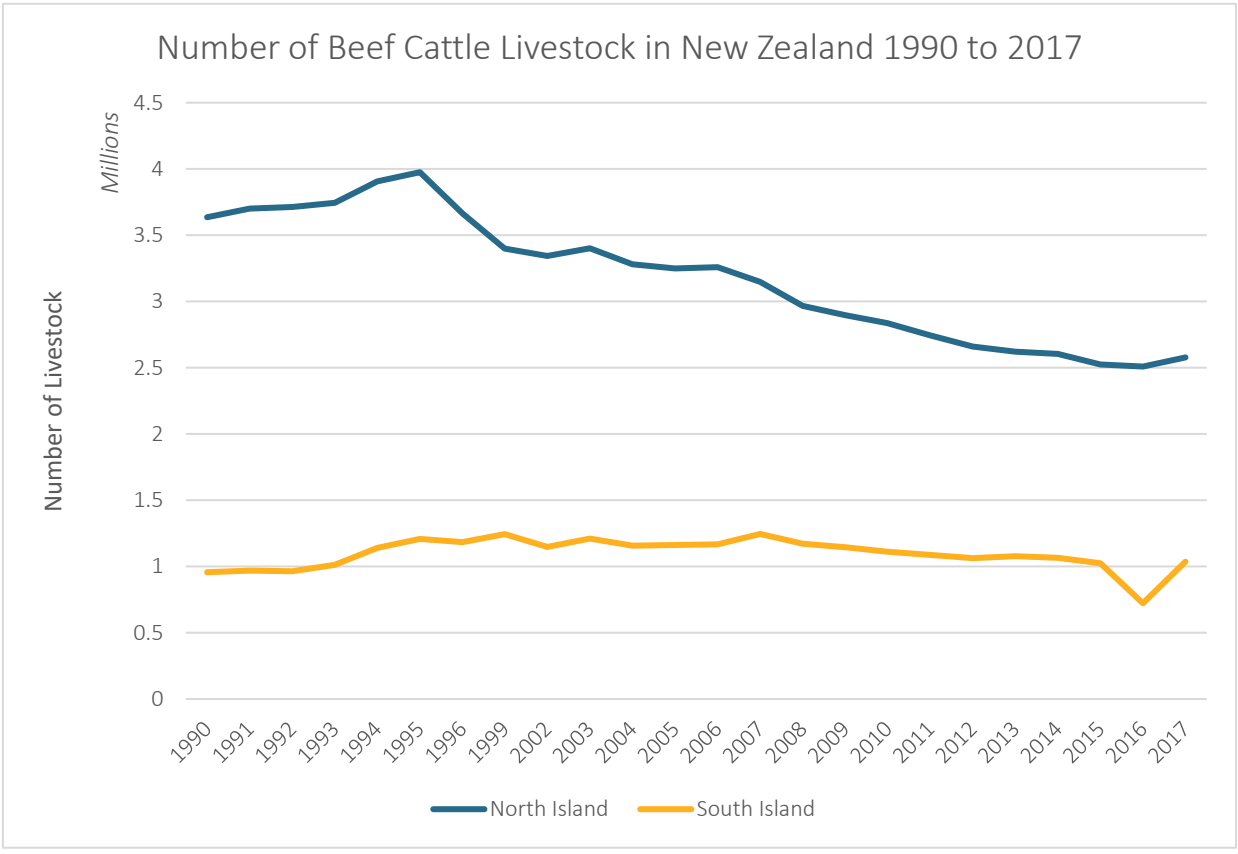


Figure 4.27 Number of Beef Cattle Livestock in New Zealand, 1990 to 2017 (Statistics New Zealand, 2018d)

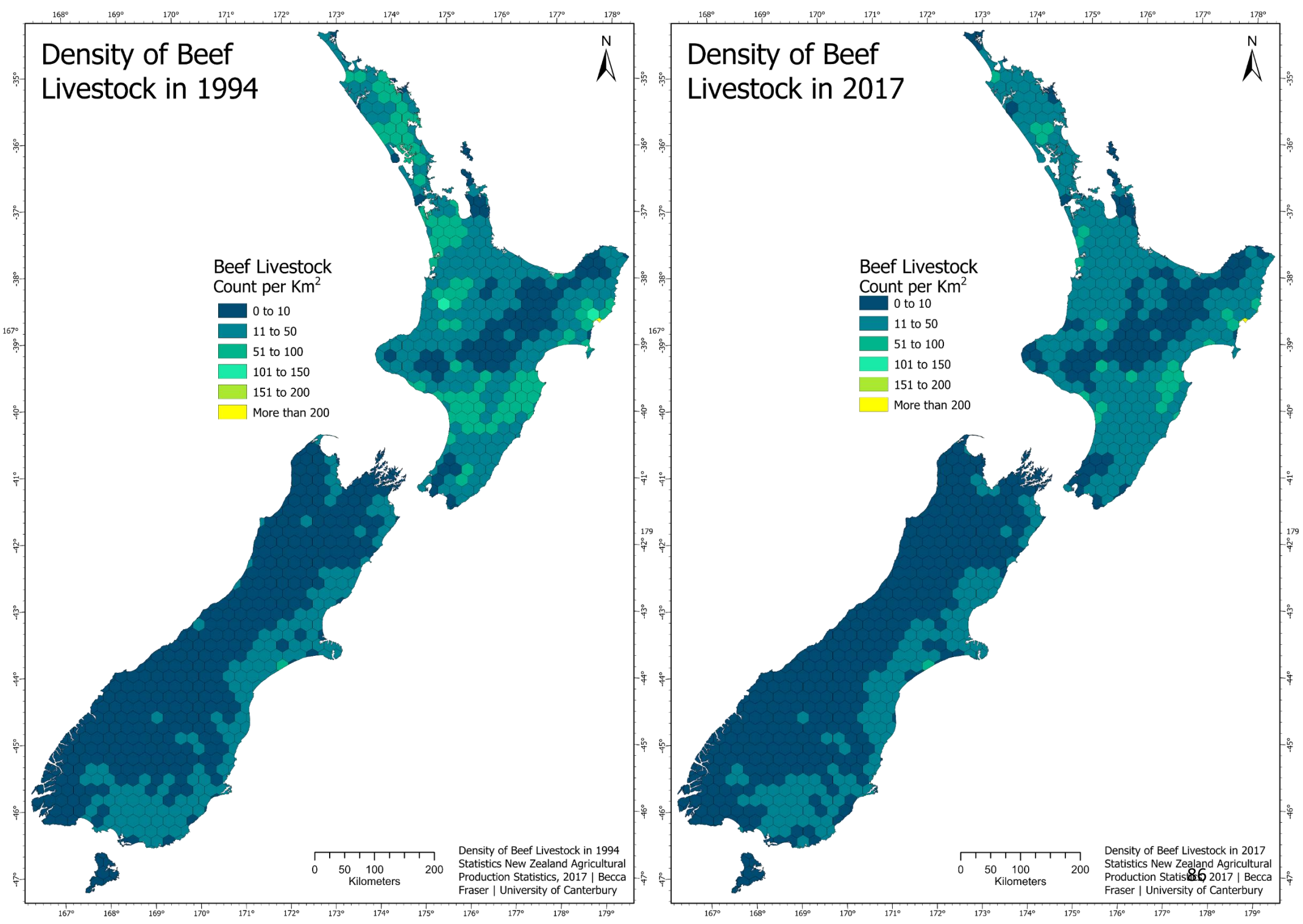
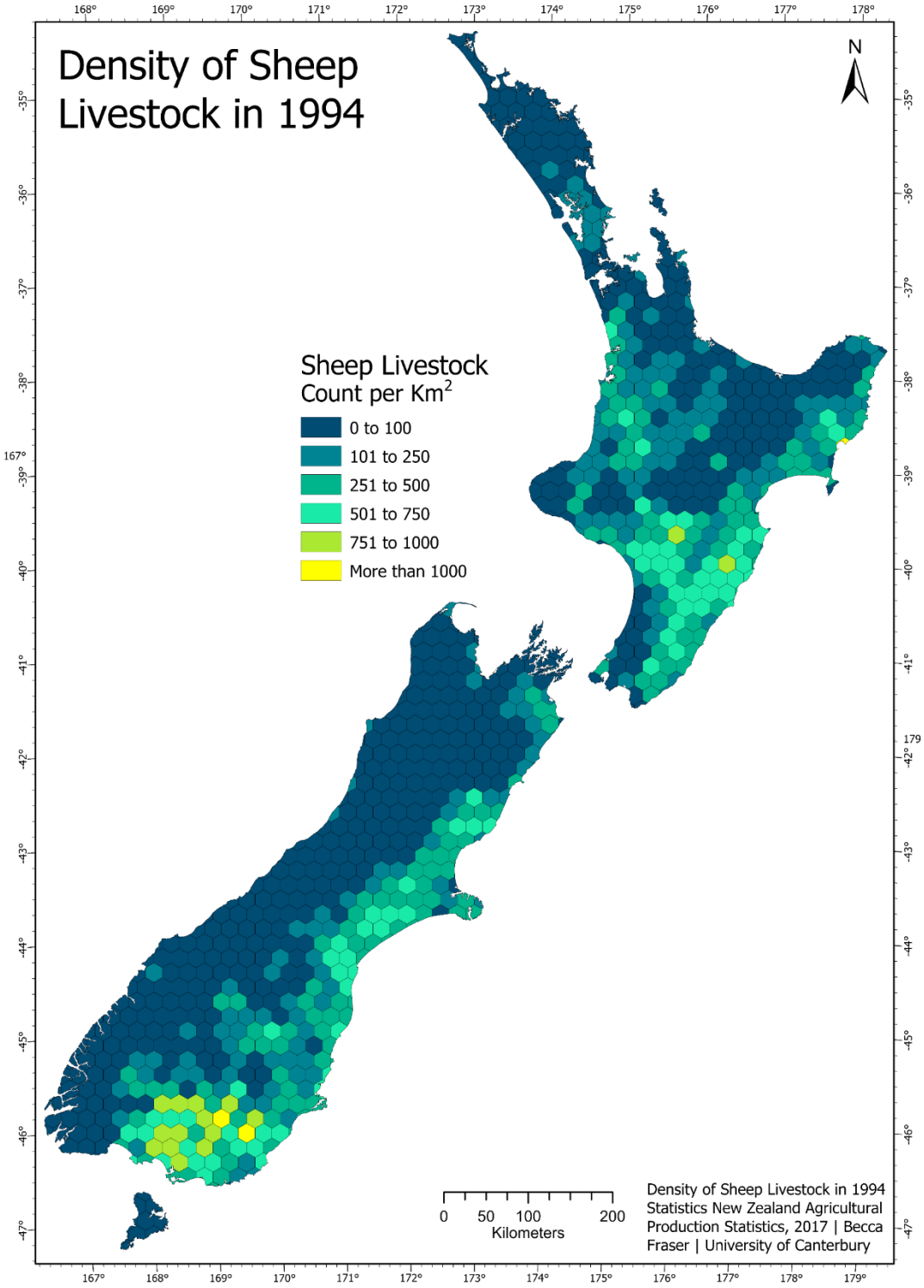


Figure 4.28 Density of Beef Livestock between 1994 and 2017 (Statistics New Zealand, 2018d)



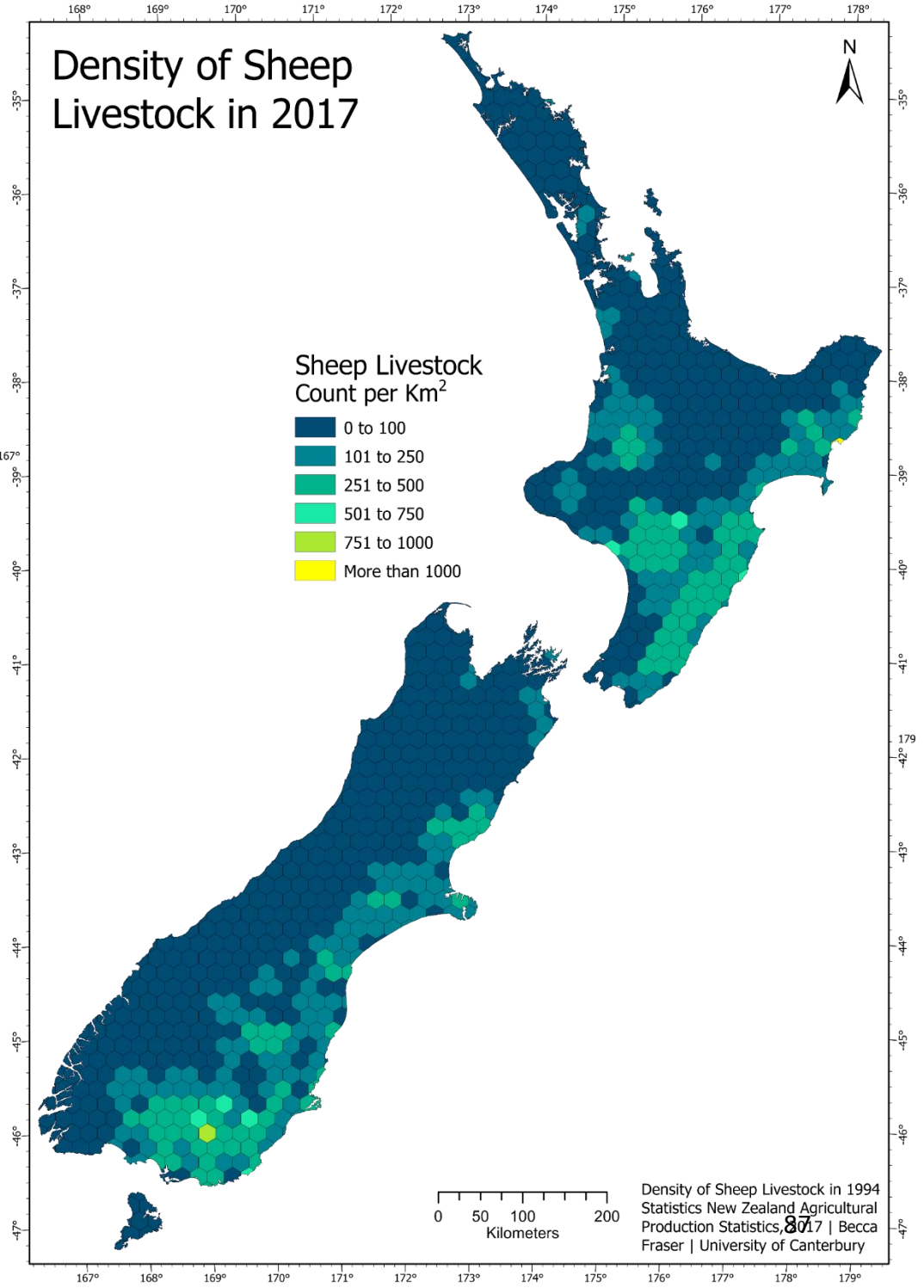


Figure 4.29 Density of Sheep Livestock between 1994 and 2017 (Statistics New Zealand, 2018d)

4.3.2.1 Dairy

The export of dairy products in New Zealand began with the advent of refrigerated shipping in 1882. Until the 1990s, the dairy industry consisted of hundreds of different dairy cooperatives, many of which exported to Britain. Between 1993 and 2001 the number of cooperative dairy companies fell from 499 to 4 (Evans, 2004). In 2001 the dairy industry was restructured to reduce inefficiency and achieve better economies of scale, through the Dairy Industry Restructuring Act 2001 (Evans, 2004). This resulted in the merger of existing dairy cooperatives and the formation of the Global Dairy Company (which later became Fonterra Co-operative Group) (Evans, 2004). By the end of 2001, Fonterra represented almost 13,000 farmers and 96% of raw milk produced in New Zealand, with almost all product delivered to consumers in export markets. By 2018, Fonterra employed 20,000 people, contributed 25% of New Zealand's total exports and had over 30 manufacturing sites across New Zealand (Fonterra, 2018).

Following the deregulation in 2001, rural New Zealand saw areas of huge growth and conversion to dairy farming, with milk production continually growing. Often colloquially referred to as the 'dairy boom' many sheep and beef farmers converted to more intensive dairy farming (Rawlinson et al., 2013). The total area of dairy farms increased by 32% between 2001 and 2017 and the average herd size climbed from 251 to 431 cows in the same time period (NZ Dairy Statistics, 2017). 72% of dairy herds are located in the North Island, but 41% of dairy cows are located in the South Island and Canterbury has 14% of all dairy cows in New Zealand. Growth in the dairy industry was driven by prolonged periods of prosperity in the dairy industry, in comparison to leaner times in sheep, beef and arable farming (Rawlinson, Tipples, Greenhalgh & Trafford, 2013). Figures 4.30 indicates that the number of dairy cows in the North Island grew by 27% and in the South Island by 680% between 1990 and 2017. Figure 4.31 presents this spatial change with intensification of dairy livestock notable in Canterbury. The introduction of irrigation, particularly in drier areas of the South Island also allowed large scale conversion to dairy (see Figure 4.46). Supplementary livestock maps are provided in appendix C.1.

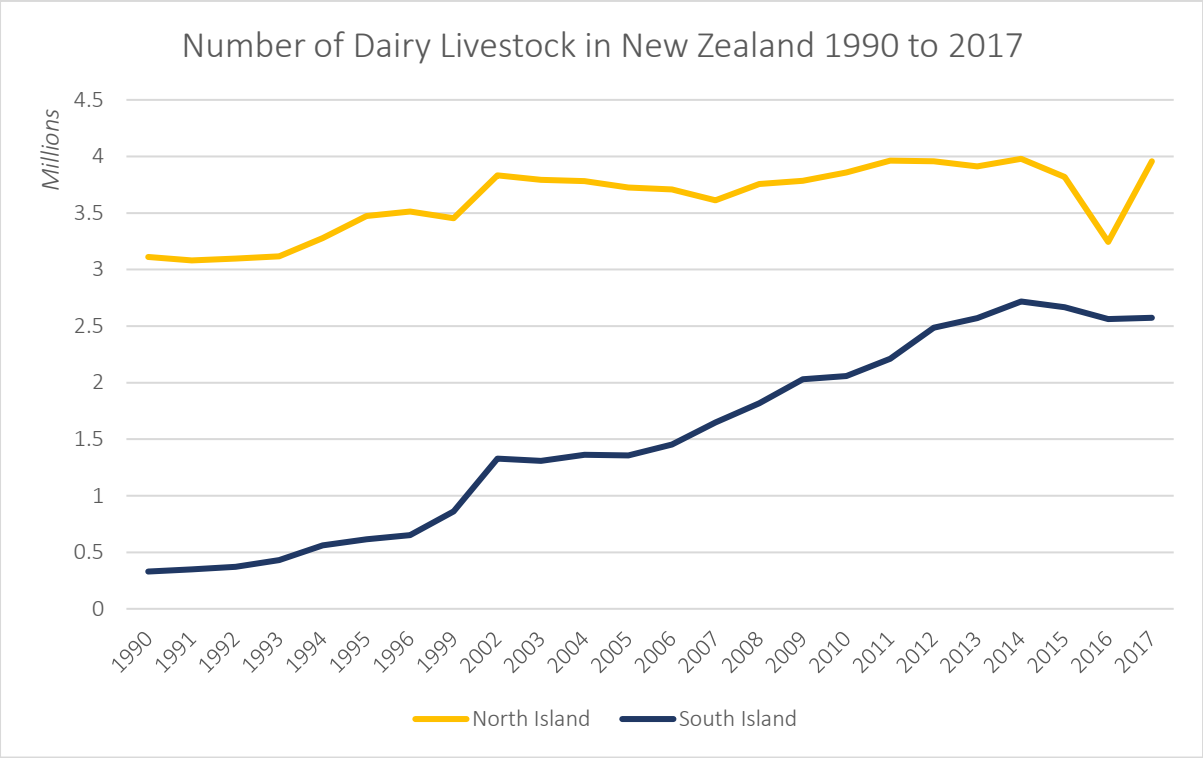
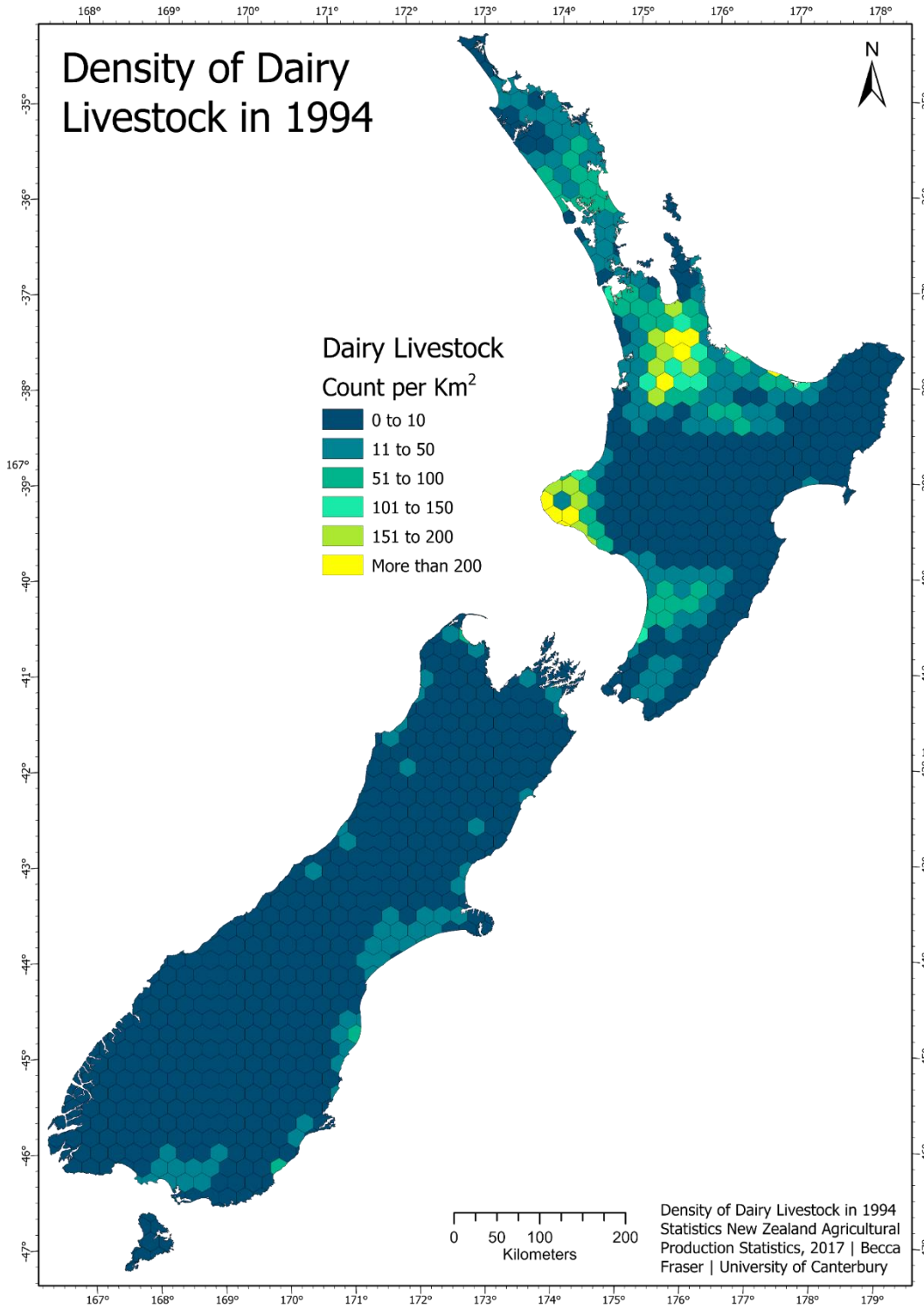


Figure 4.30 Number of Beef Cattle Livestock in New Zealand, 1990 to 2017 (Statistics New Zealand, 2018d)



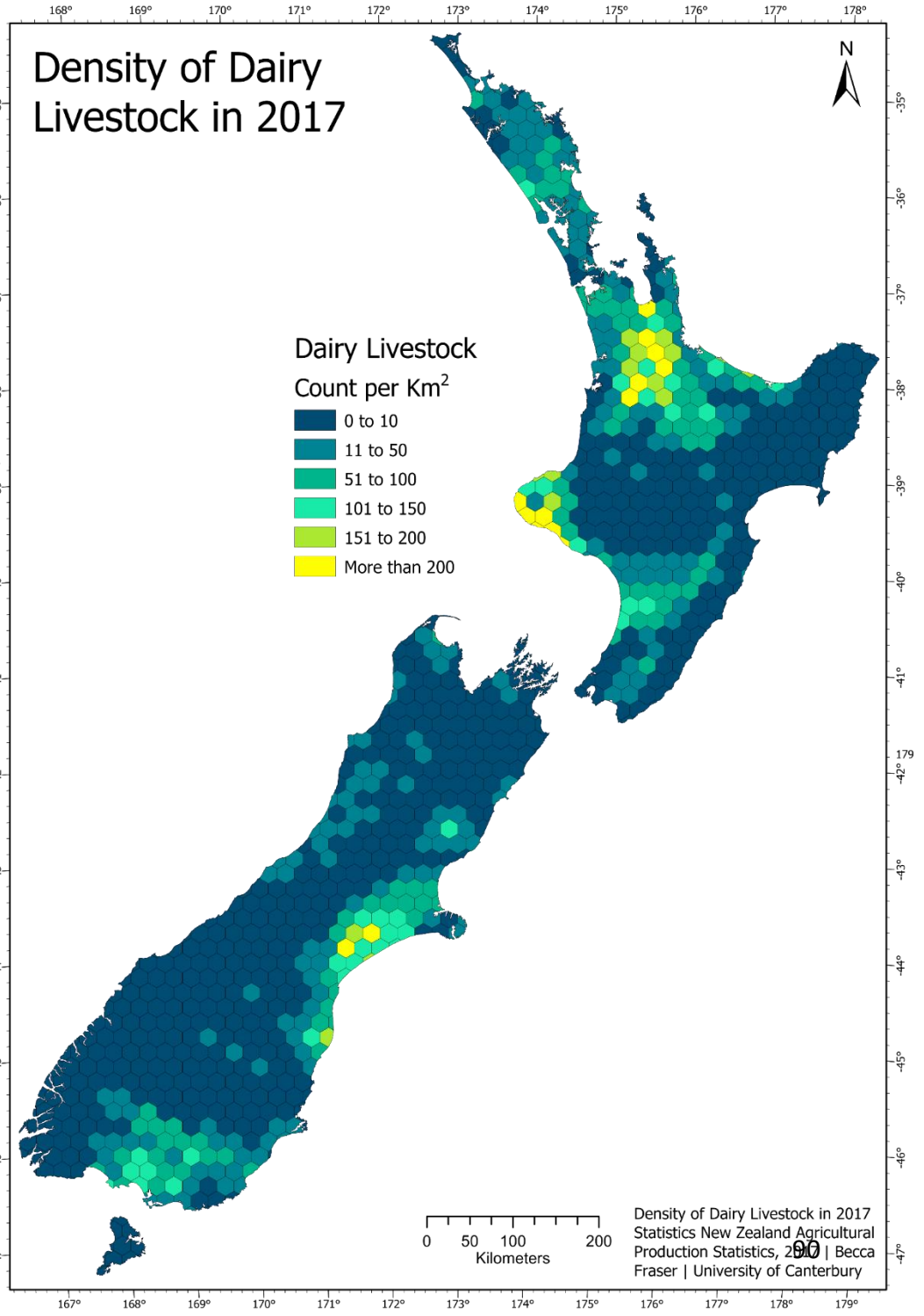


Figure 4.31 Density of Dairy Livestock between 1994 and 2017 (Statistics New Zealand, 2018d)

4.3.2.2 Wine Industry

Another agricultural land use change is the growth in viticulture. The wine industry has experienced sustained growth from 1999 to 2012, with the majority of this expansion taking place in the south island (Figures 4.32 and 4.33). Figure 4.32 shows this growth, from 190 million litres of wine produced in 2010 to 297 million litres in 2019 (New Zealand Winegrowers Association, 2019). Figure 4.34 indicates that these vineyards are densely concentrated, in areas like Marlborough and Hawke's Bay.

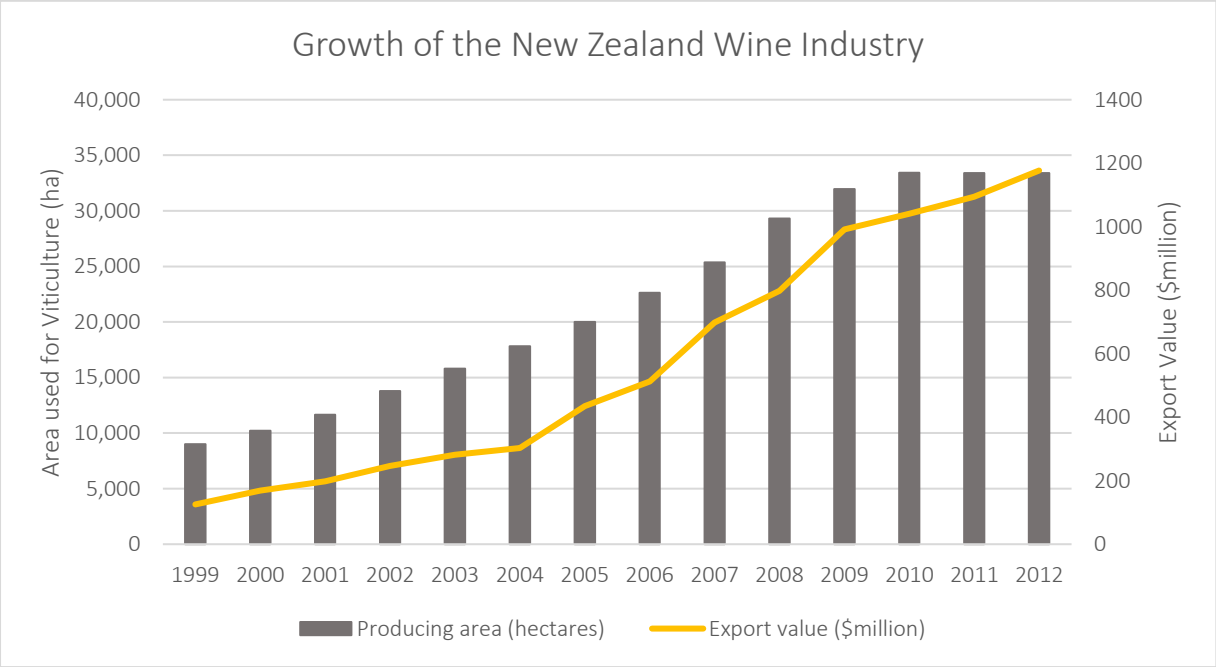


Figure 4.33 Growth of the New Zealand Wine Industry (Nominal) (Agricultural Production Statistics, 2013)

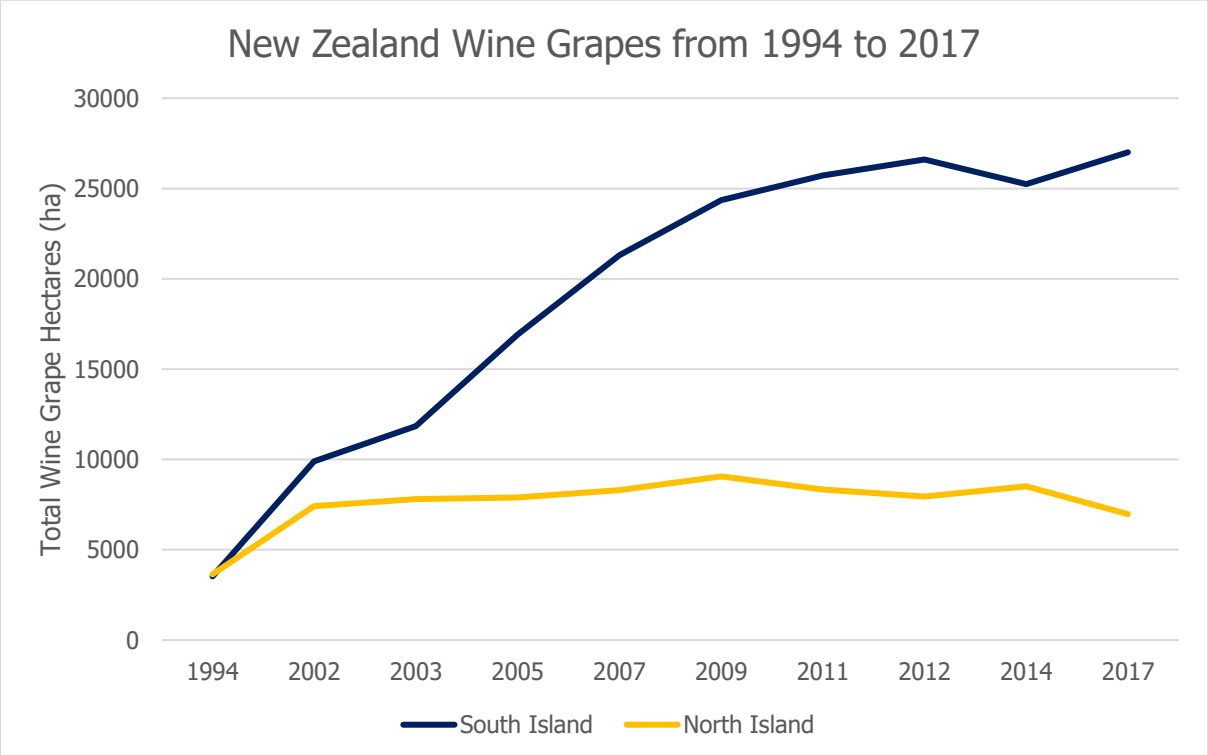


Figure 4.32 Total Wine Grape Hectares between 1994 and 2017

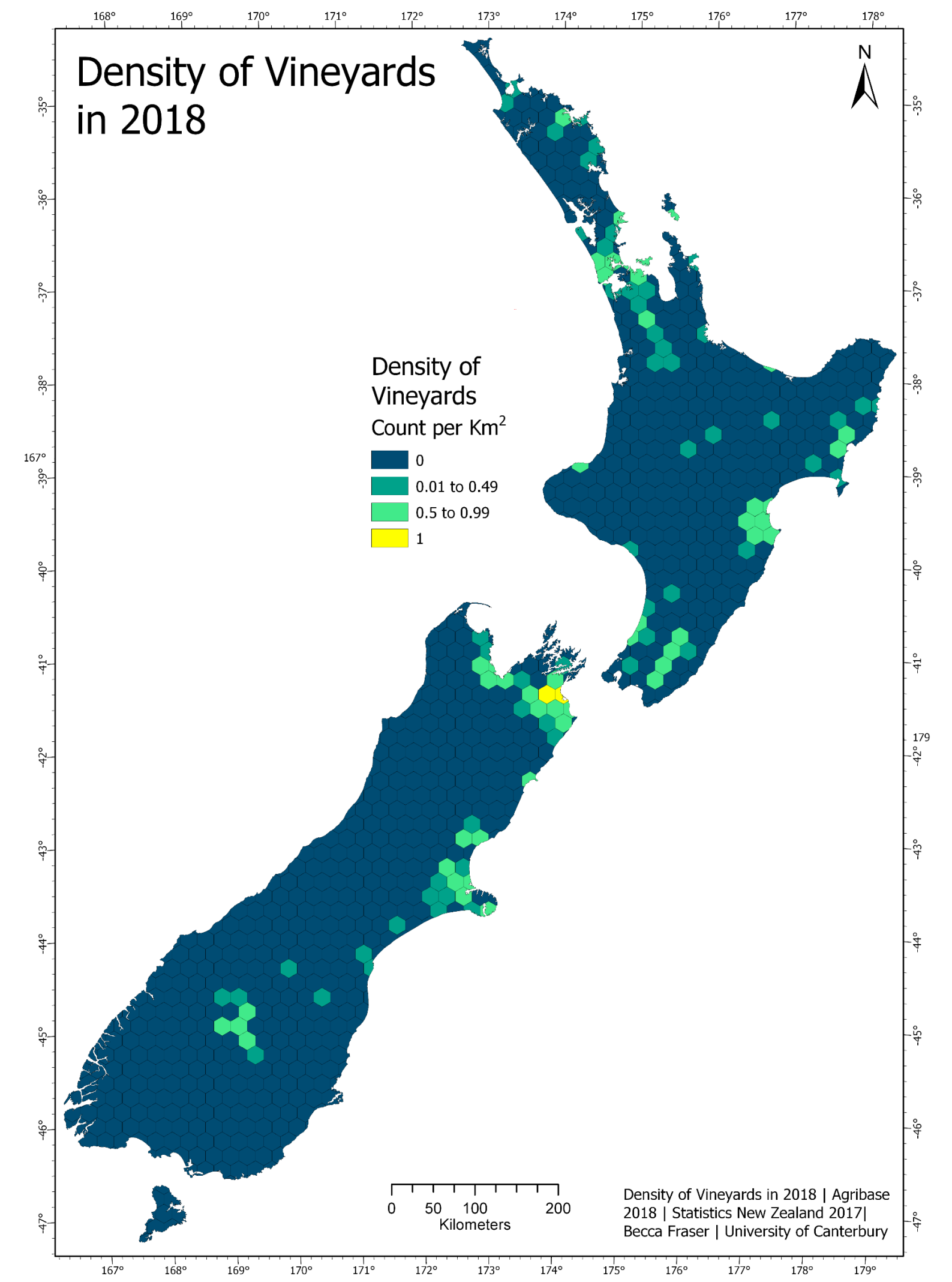


Figure 4.34 Density of Vineyards in 2018 (Agribase, 2018)

4.3.3 Limitations

Using livestock units could be inaccurate measure of farming change as the size and productivity outputs of stock have changed and also diversification in farm types has occurred (Macleod & Moller, 2006). This could potentially be supplemented by using indicators like the stock carrying capacity of agricultural land, fertilisation, or energy use.

4.4 Economic Trends

An important factor in rural resilience is economic change; potential indicator datasets for changing rural economic trends are:

- Industry Exports
- Agricultural GDP

New Zealand's rural economy has undergone periods of restructuring, socioeconomic and political change, and the impacts of shifting global markets (Wilson, 1995). In the 1960s, agricultural exports accounted for 90% of New Zealand's total export earnings (Evans, 2004). In 1984 agriculture contributed 36% of total exports (Pomeroy, 2015). 1984 marked the beginning of change in the New Zealand rural economy. Sweeping economic reforms, commonly referred to as 'deregulation' removed structural subsidies, tax and other fiscal incentives such as price controls that previously protected the agricultural sector (Smith, 2006). Production subsidies for things like fertiliser, funding for drought and flood relief, and support for irrigation was also removed. The deregulation exposed farmers to global market forces, and also impacted rural communities too (Smith & Montgomery, 2004).

Before the economic reforms, government assistance to agriculture was approximately 33% of output value (Smith & Montgomery, 2004). The majority of this supported sheep and beef farms, with government assistance comprising almost 40% of sheep and beef farm income (Smith & Montgomery, 2004). Consequently, this meant the withdrawal of government support had very different regional and industry impacts. Many sheep and beef farmers suffered substantial financial impacts, while impacts to horticulture, dairy and cropping farming were less severe (Smith & Montgomery,

2004). By 1987, lower farm incomes and high interest rates collapsed land prices by anywhere from 50%-70% (Smith & Montgomery, 2004). In 1972 primary industries accounted for a 12% share of the New Zealand economy (agriculture, forestry, fishing and mining services), in 2018 this share had dropped to 7% (Statistics New Zealand, 2019a).

The combined impact of high levels of debt, falling commodity prices and increased costs drove changes in rural social conditions that continue reverberate today (Chalmers & Joseph, 1998; Smith & Montgomery, 2004). Smith and Saunders (1995), noted that ten years on from the reforms, many sheep and beef farmers were still experiencing environmental, economic and personal impacts following the change. Researchers estimate that for every one dollar not spent by farmers, it is estimated that another three dollars was not spent in the rural services sector (Walker & Bell, 1994). This included things like meat processing plants, many of which closed as sheep numbers fell, sometimes the loss of a major employer for small rural towns (Walker & Bell, 1994; Press & Newell, 1994). This was compounded by economic reforms also taking place in other sectors such as healthcare and education.

Unemployment in rural service communities was widespread with more than 5,000 people made redundant from jobs in the post office, forestry, railways and mining (Pomeroy, 2019). The small town of Patea (South Taranaki) is one example of this dependence on agricultural support services, 70% of the population were employed at the freezing works in the town, most of whom became unemployed when it closed, while some residents moved many were unable to sell their homes, or lacked the skills to move to different employment (Pomeroy, 2019; Peck, 1985). Efforts to build employment opportunities in rural areas between 1984 and 2004 resulted in the development of enterprises like Kaikōura Whale Watch tourism, generating new jobs for communities (Pomeroy, 2019; Crozier, 1997).

Pomeroy (2019)**,** notes that literature on forestry communities is scarce, but that the growth in forestry in places like the Bay of Plenty and the West Coast caused rapid rural population growth throughout the 1960s and 1970s. Subsequent privatisation of

state owned forestry with the disestablishment of the Forest Service and rationalisation of processing plants resulted in swathes of redundancies, sometimes affecting the employment base for entire rural towns, like Murupara and Minginui, built in the 1950s to house forestry workers. The early 2000s saw some conversion of forestry land to other uses in response to high land prices and low log prices, with the conversion of approximately 9000 hectares in Canterbury and 3000 hectares in the North Island for dairy farming. In 2007 a government cap was introduced on the conversion of forestry land to other uses (Roche, 2008). However exports and production have continued to grow from two million, to over twenty-five million cubic metres of exports, from 1999 to 2019 (Figures 4.35 and 4.36).

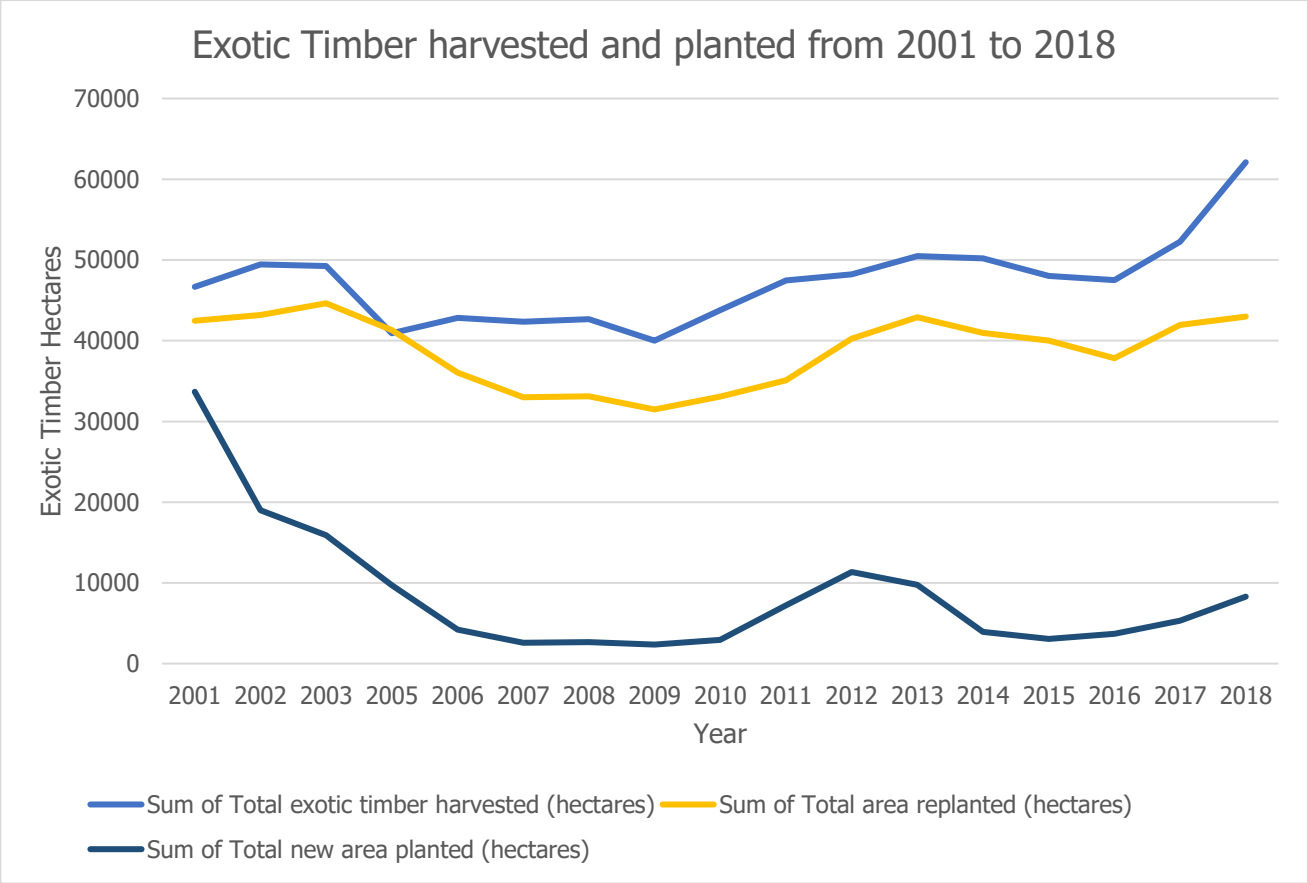


Figure 4.35 Exotic Timber harvested and planted from 2001 to 2018 (Statistics New Zealand, 2019b)

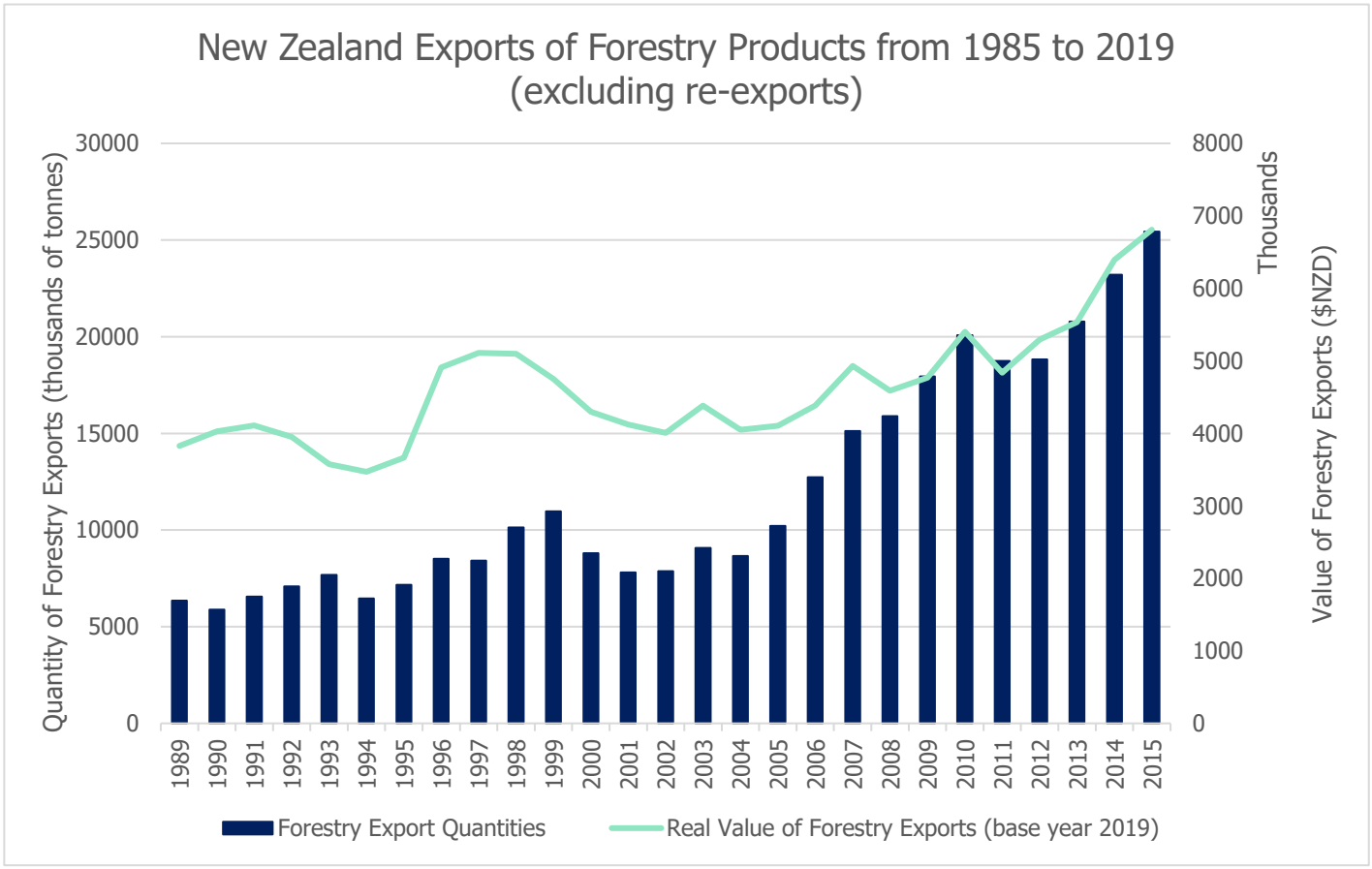


Figure 4.36 Exports of Logs and Wood from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

Different primary industries have also made different contributions to New Zealand's GDP over time. Figure 4.37 indicates that forestry has remained largely constant at between 0.5 and 1% of the GDP between 2000 and 2015. Over the same time period, sheep and beef farming has seen a general decline from 2.4% of the GDP to 1.2%. Dairy contributions have been much more variable and has reached highs of up to 3.5% of the GDP and lows of 1.3% between 2000 and 2015. Specific industries are broken down in Figures 4.36 to 4.41, these reflect the patterns of land use change in Figures 4.26 to 4.31. Wool exports decreased from 1999 and 2019, from almost 300,000 tonnes, to 104,000 tonnes, from $3.5 billion to $550 million (Figure 4.39). Figure 4.38 indicates that beef and veal exports have increased by 35% between 1989 and 2019. Figure 4.40 shows an increase of 97% in the same time period for exports of lamb and mutton. Dairy exports indicate strong growth (see Figure 4.41), the export of high value products like butter, cheese and casein has contributed to a growth in export value from $4 billion in 1989 to over $15 billion in 2019. Wine exports have seen a sharp increase in export values from under $200 million to over $1.8 billion between 1989 and 2019 (see Figure 4.42).

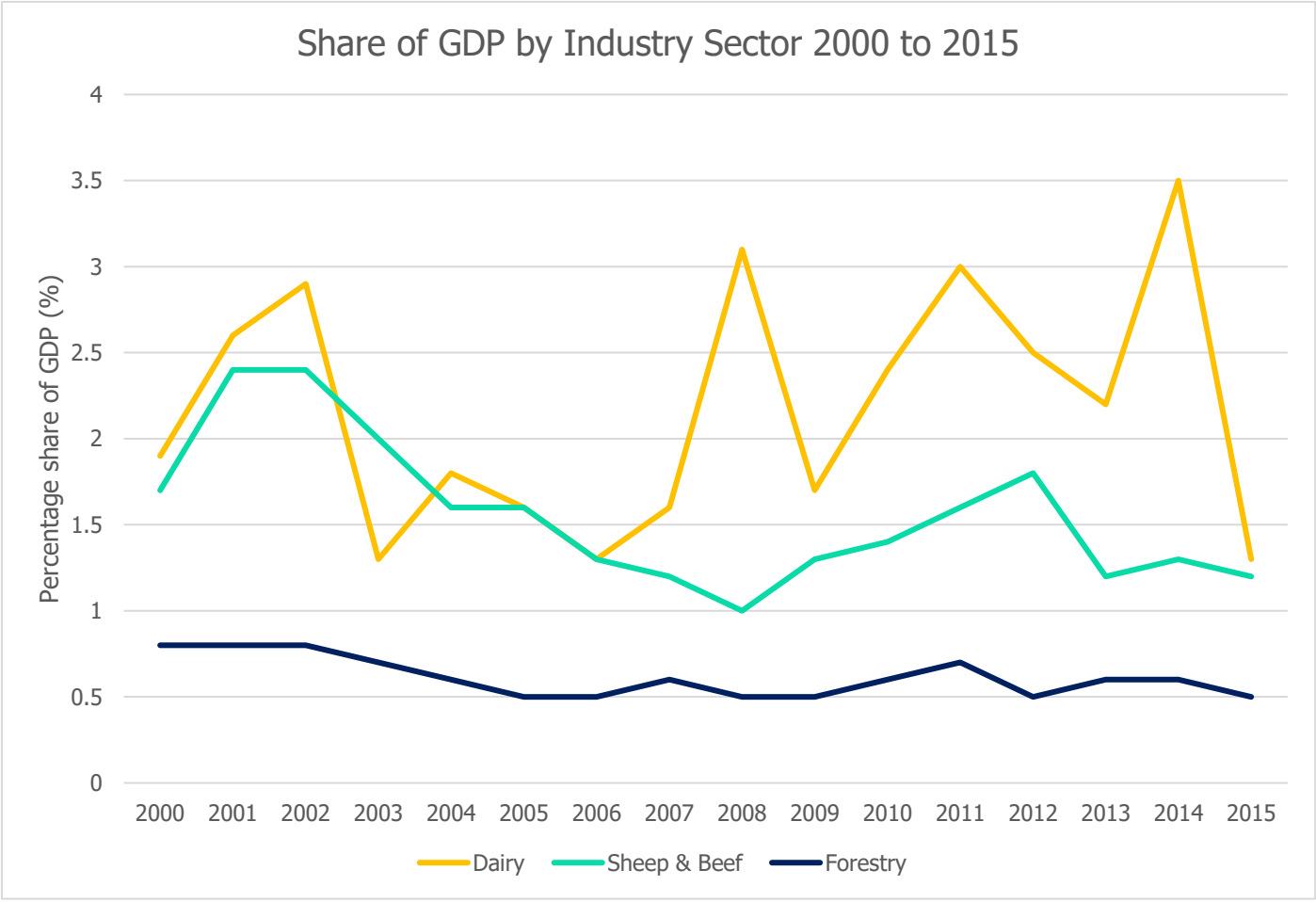


Figure 4.37 Share of GDP by industry sector (Statistics New Zealand, 2019a))

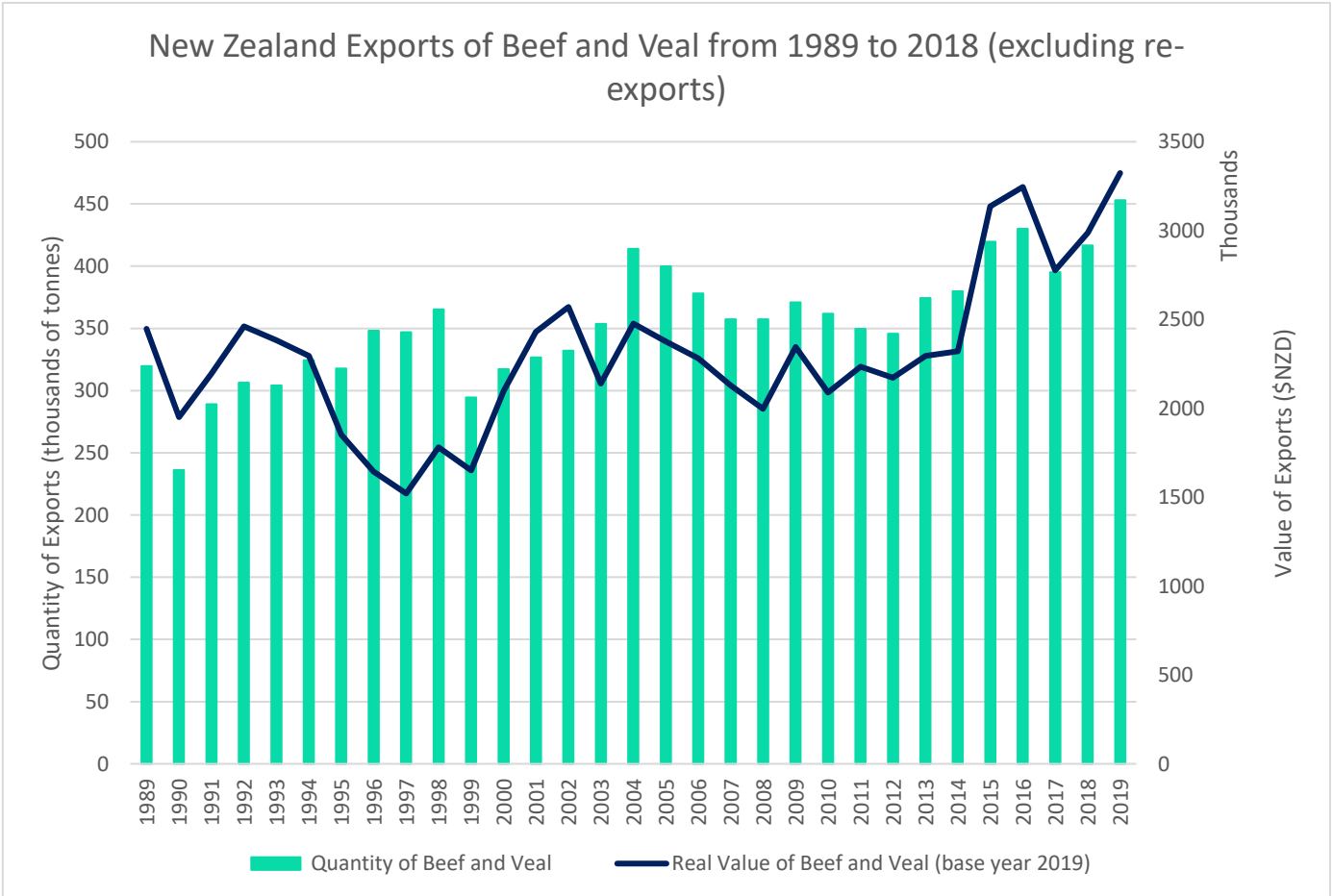


Figure 4.38 Exports Beef and Veal from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

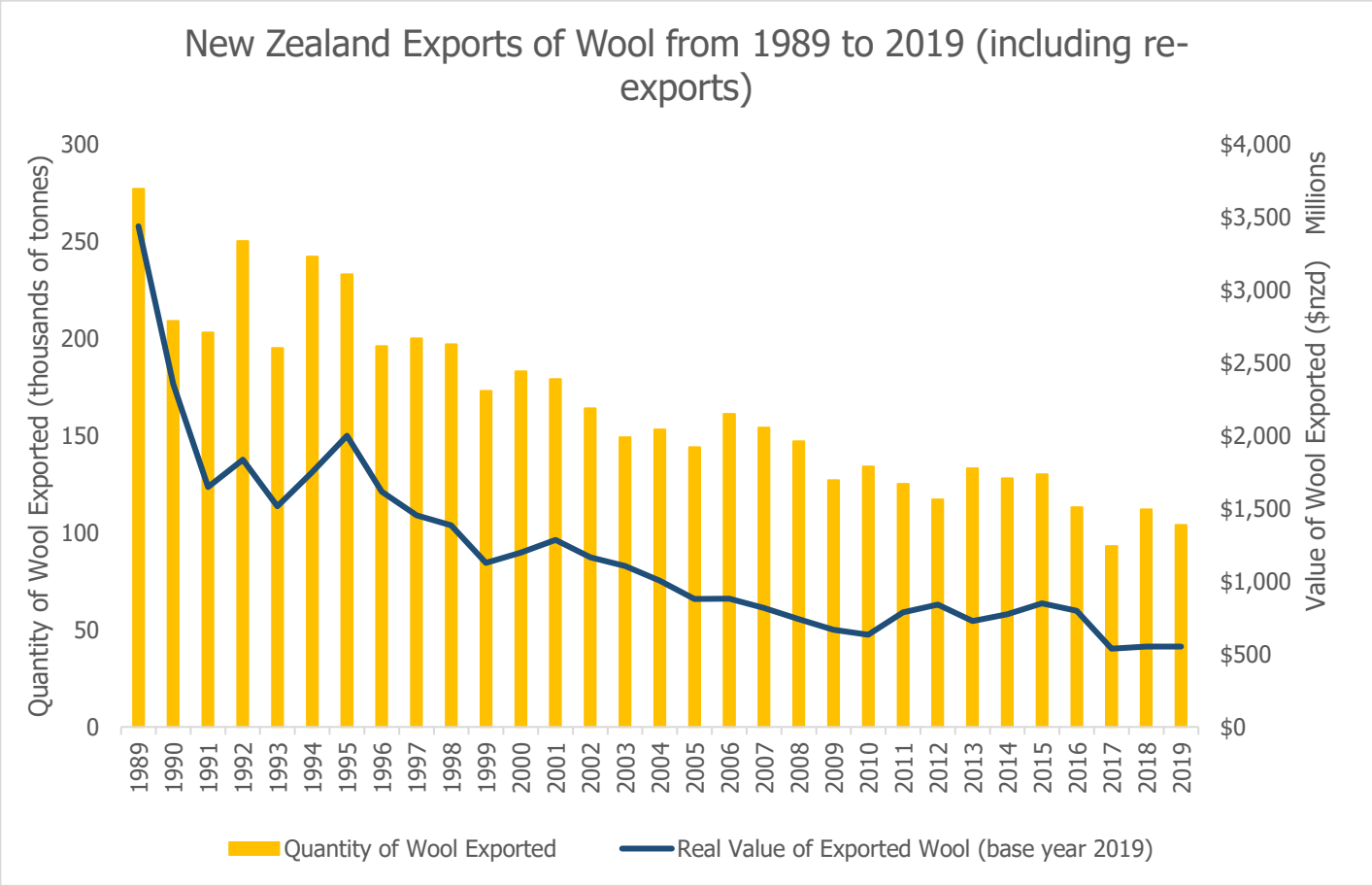


Figure 4.39 Exports of Wool from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

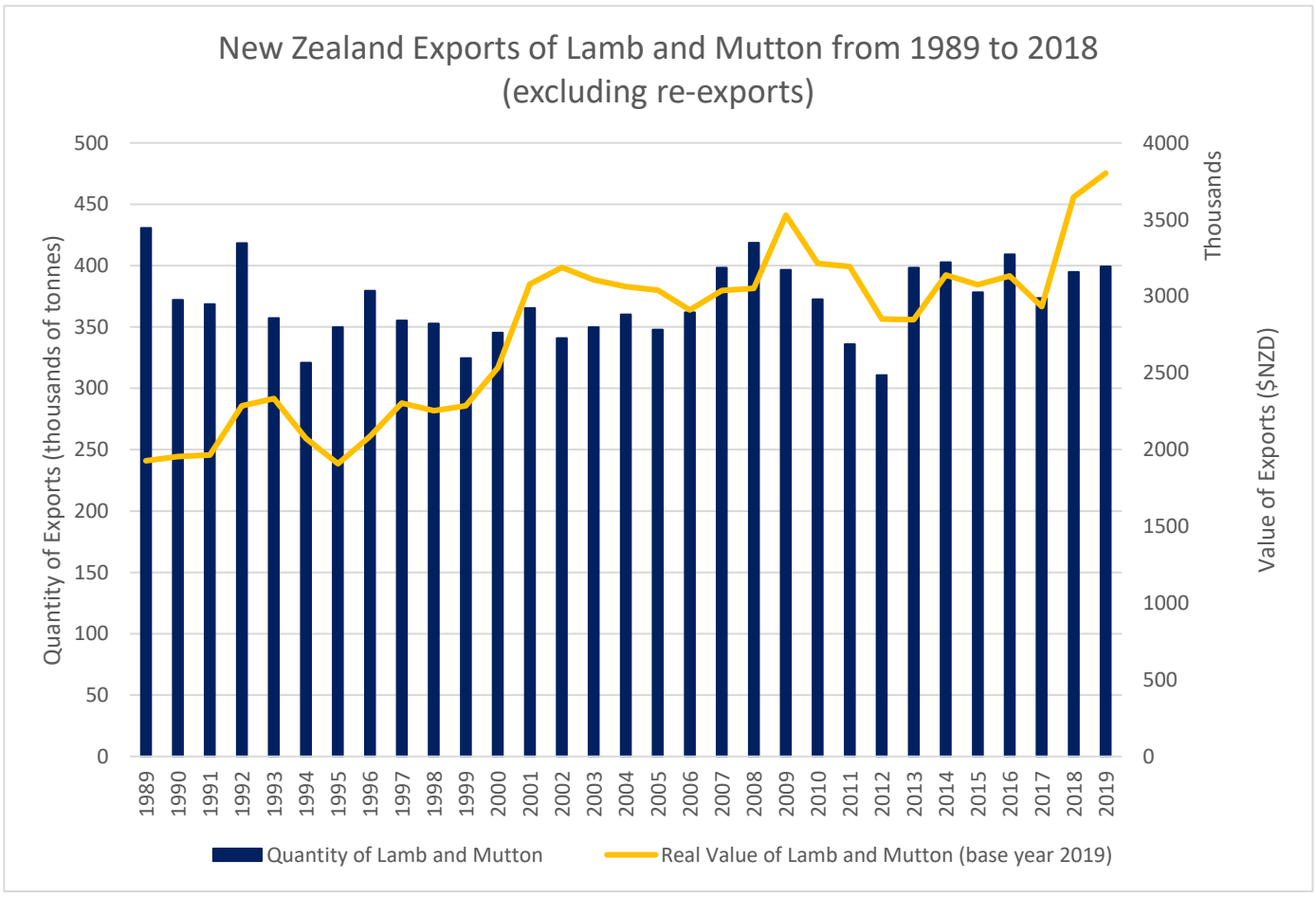


Figure 4.40 Exports of Lamb and Mutton from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

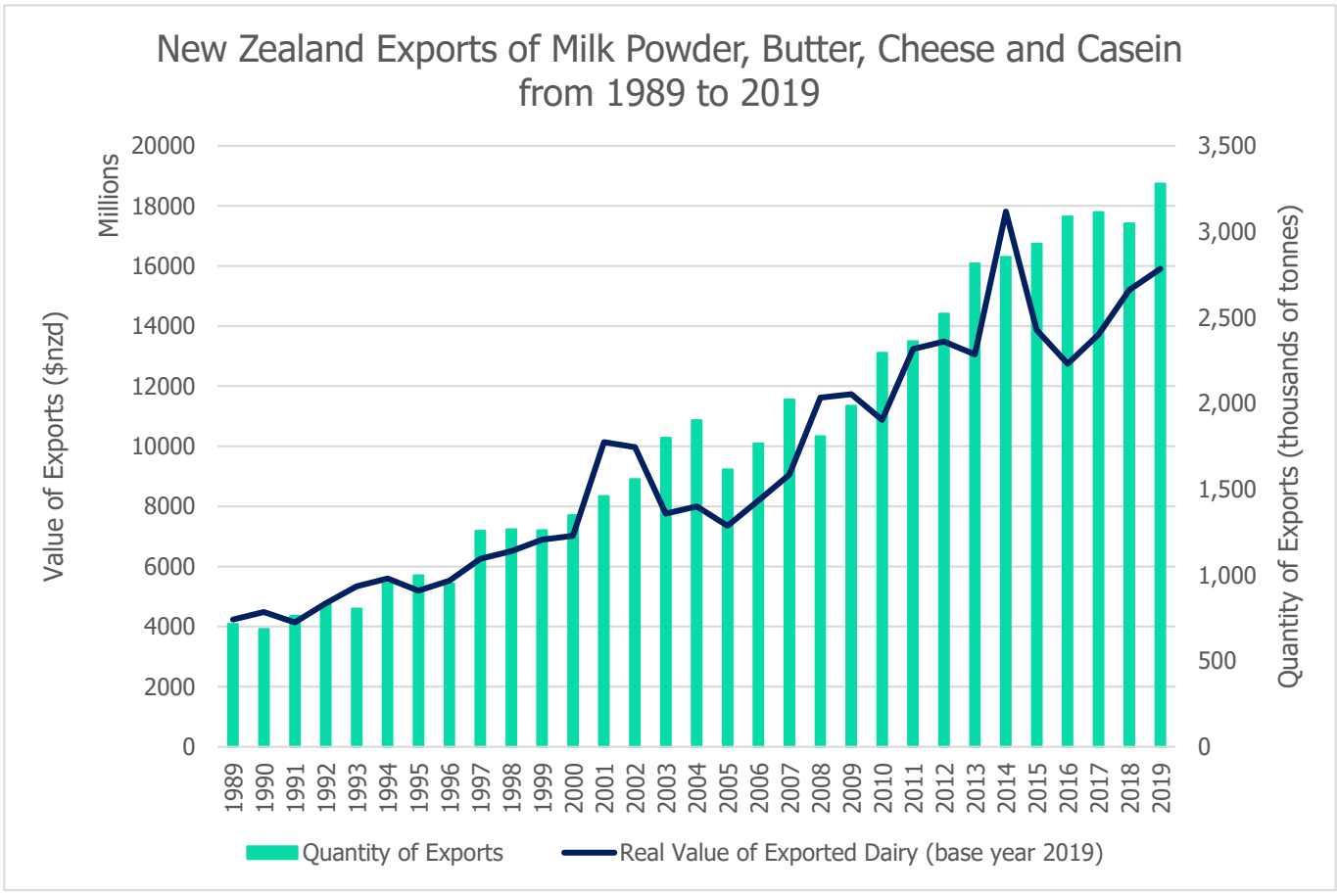


Figure 4.41 Exports of Dairy Products from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

Figure 4.42 Exports of Wine from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

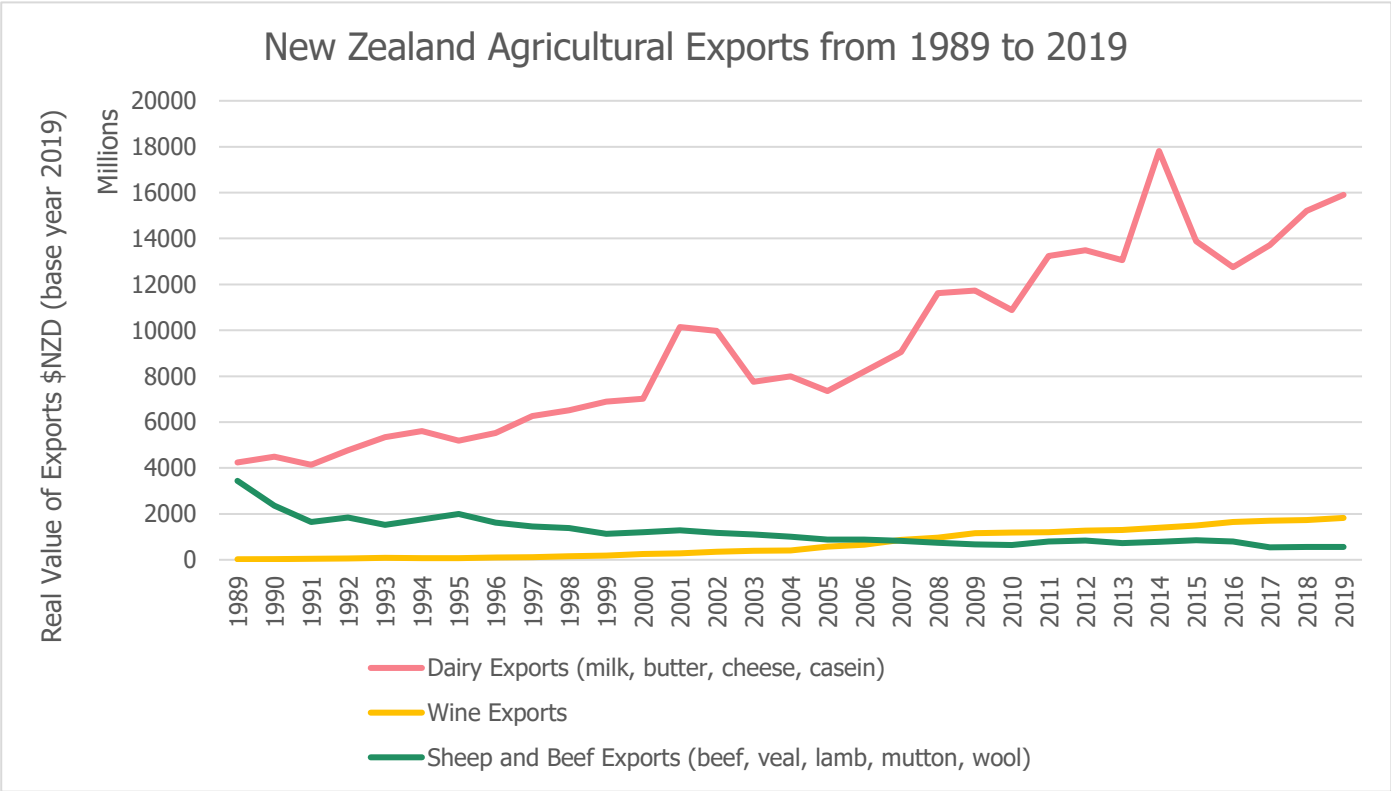
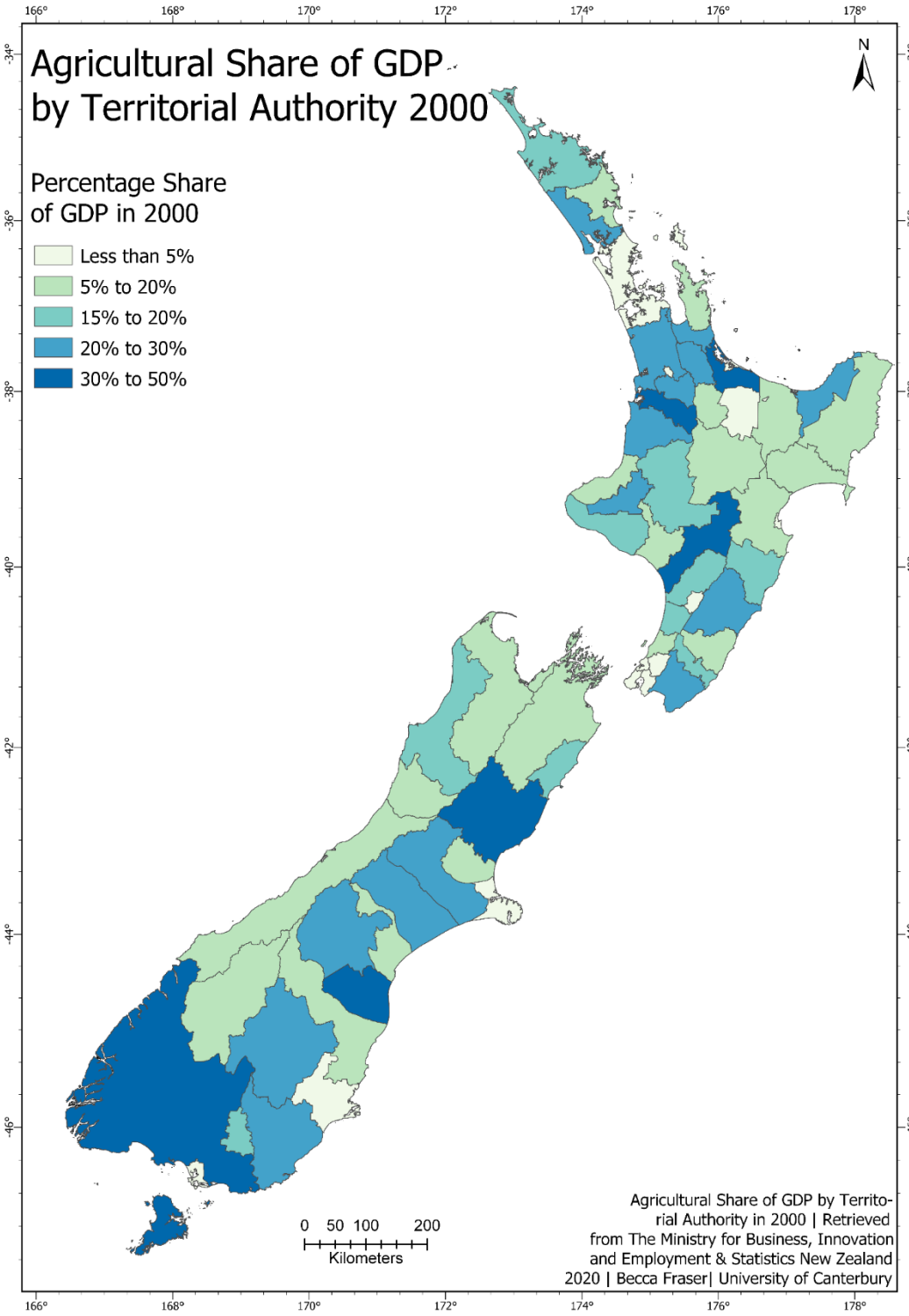


Figure 4.43 Exports of Agricultural Products from New Zealand 1989 to 2019 (Overseas Merchandise Trade: Quantity and Value of Principal Exports (including re-exports) (Annual-Jun) 2019b)

Figure 4.43 indicates that the value of wine exports overtook sheep and beef exports in 2007. Dairy exports have seen an increase in annual export values of 275% between 1989 and 2019. These changing land use types and exports values are also reflected in geographical differences. Figure 4.44 indicates that some regions have a changing economic dependence on agriculture. The Queenstown-Lakes District has shifted from between 5%-20% dependence on the agriculture industry, to less than 5% between 2000 and 2017. This is potentially related to the growth of tourism in centres like Queenstown and Wanaka. The West Coast region has seen an increased dependence on Agriculture from 5% to 20% to between 20% and 30%. This could be due to the growth of the dairy industry in this region.

4.4.1 Limitations

Most rural economic data is agriculturally focused, for example, the National Accounts dataset defines rural as those in agriculture, forestry, fishing and mining services, which does not create a full picture of the rural economy, such as those in rural tourism or retail. There is limited data on the economic changes experienced by non-agricultural rural community members and services. Additionally, different data sources have different and often subjective definitions of rural.



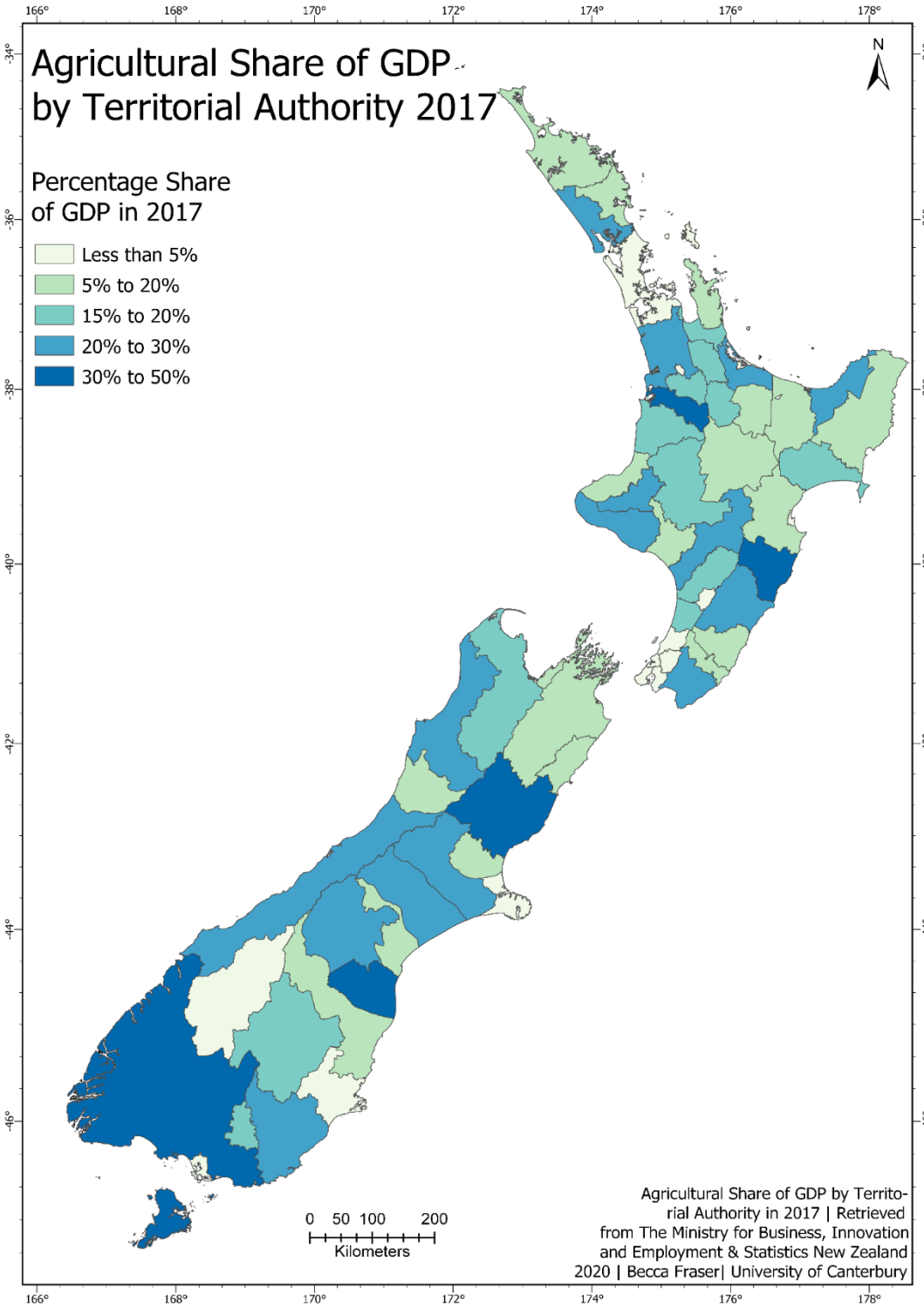


Figure 4.44 Agricultural Share of GDP by Territorial Authority in 2000 and 2017 (Statistics New Zealand 2018e; Ministry for Business, Innovation and Employment, 2017)

4.5 Technological Trends

Future technological trends are an important consideration for rural disaster resilience as innovation in agricultural practice could improve agricultural outputs. Land use intensification and diversification have been partly driven by the development of farming technology like aerial topdressing in the 1940s (Molloy, 1980; Langer, 1990). Climate change mitigation and adaptation technologies may also affect future rural resilience (Frieling & Warren, 2018). The literature and data reviews identified two potential indicator datasets for changing technological trends:

- Irrigation
- Broadband
- Agricultural Research & Development

4.5.1 Research & Development

Statistics New Zealand's Research and Development (R&D) survey measures the level of research and development activity and expenditure by industry. R&D is generally defined as investigative work in the development of new or enhanced materials, products or services (Statistics New Zealand, 2018c). Figure 4.45 indicates that total expenditure on R&D has increased from $78 million to $100 million between 2008 and 2018.

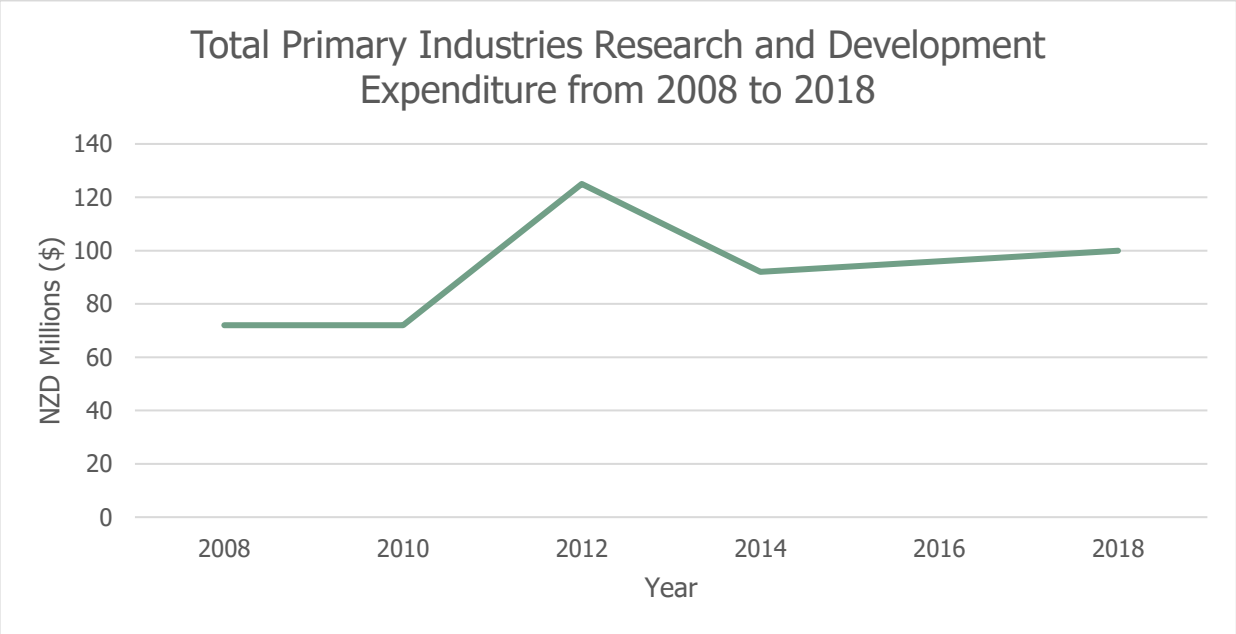


Figure 4.45 Total Primary Industries Research and Development from 2008 to 2018 (Research and Development Survey: Total research and development expenditure by industry (Annual-Jun) 2018)

4.5.2 Irrigation

In New Zealand, investment in irrigation technology and infrastructure has allowed farm intensification and conversion to higher value land uses like dairying, notable in regions like Canterbury. There has been a 94% increase in irrigated agricultural land in New Zealand (Statistics New Zealand, 2017c). Figure 4.46 shows this growth with a notable increase in the Canterbury region in particular. In 2017, irrigation covered 3% of New Zealand's land area with 64% of irrigated land in Canterbury. Dairy farms are the biggest users of irrigation, with 59% of irrigation in New Zealand. This is followed by other livestock (17%), grain (13%) and horticulture (11%) (Statistics New Zealand, 2017c). The growth in irrigation use, particularly in Canterbury has been closely associated with changing land use, such as dairy farming.

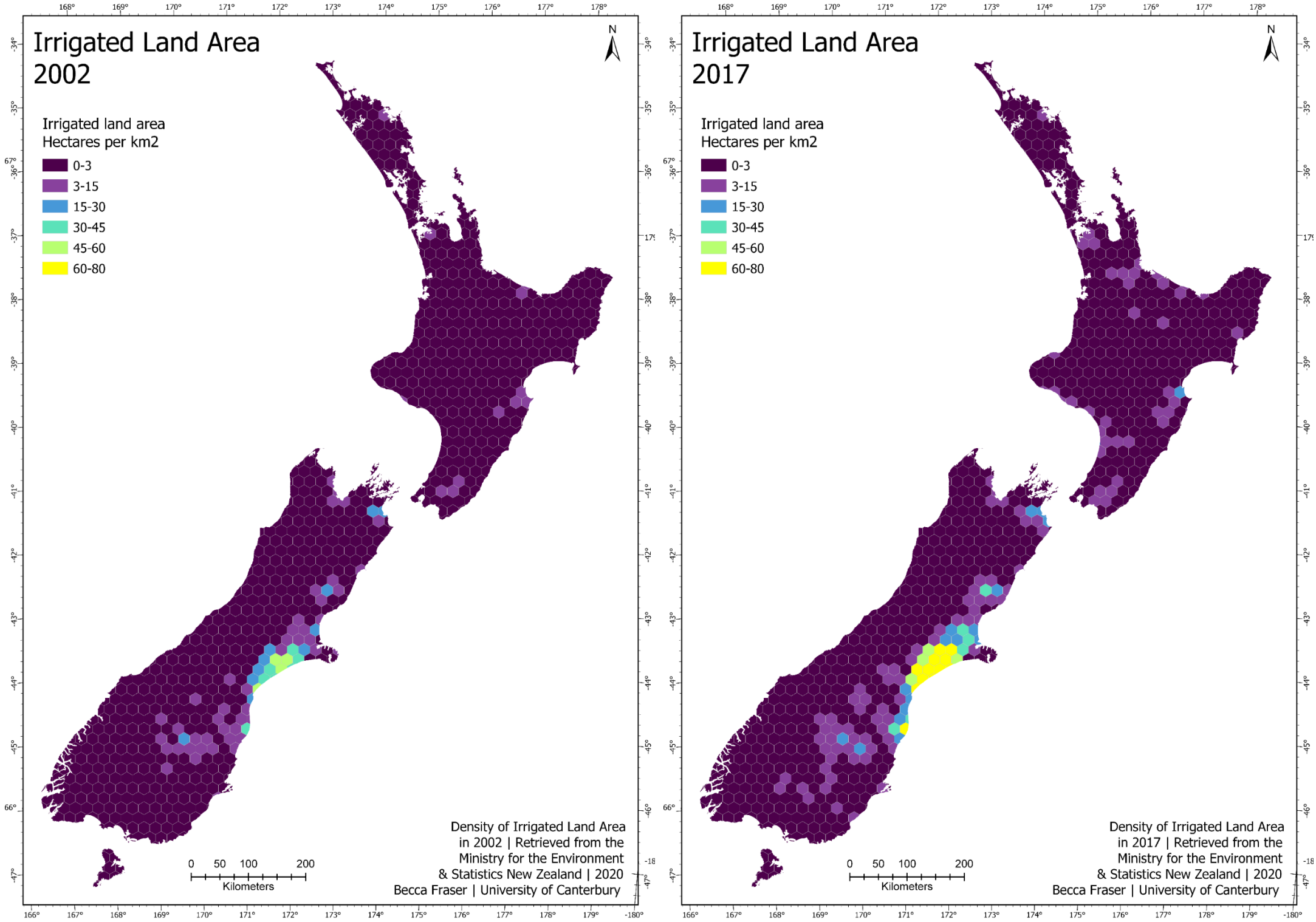


Figure 4.46 Irrigated Land Area in New Zealand in 2002 (Ministry for the Environment & Statistics New Zealand, 2017c)

4.5.3 Broadband

Technological change such as access to broadband and telecommunications means that services no longer need to have a physical presence in the community. However it also paves the way for new business and agricultural technologies. The accessibility of rural broadband has in some ways counteracted some of the impacts of service rationalisation. Improvements in broadband access have been driven by programmes like the Rural Broadband Initiative (RBI). It was implemented to provide broadband to rural schools, health providers, libraries and rural residents in New Zealand (Statistics New Zealand, 2013a). The aim of the RBI was to overcome the technical and financial difficulties of providing broadband to rural areas with low population densities and difficult terrain. The RBI resulted in over 1000 rural schools, 39 health centres and 183 rural libraries connected to fibre (Chorus, 2016). The growth of broadband is outlined in Figures 4.47 and 4.48. Rural access to broadband improved from 58% of households to 84% in rural centres between 2006 and 2012, in rural areas broadband access increased from 22% to 68% between 2006 and 2012.

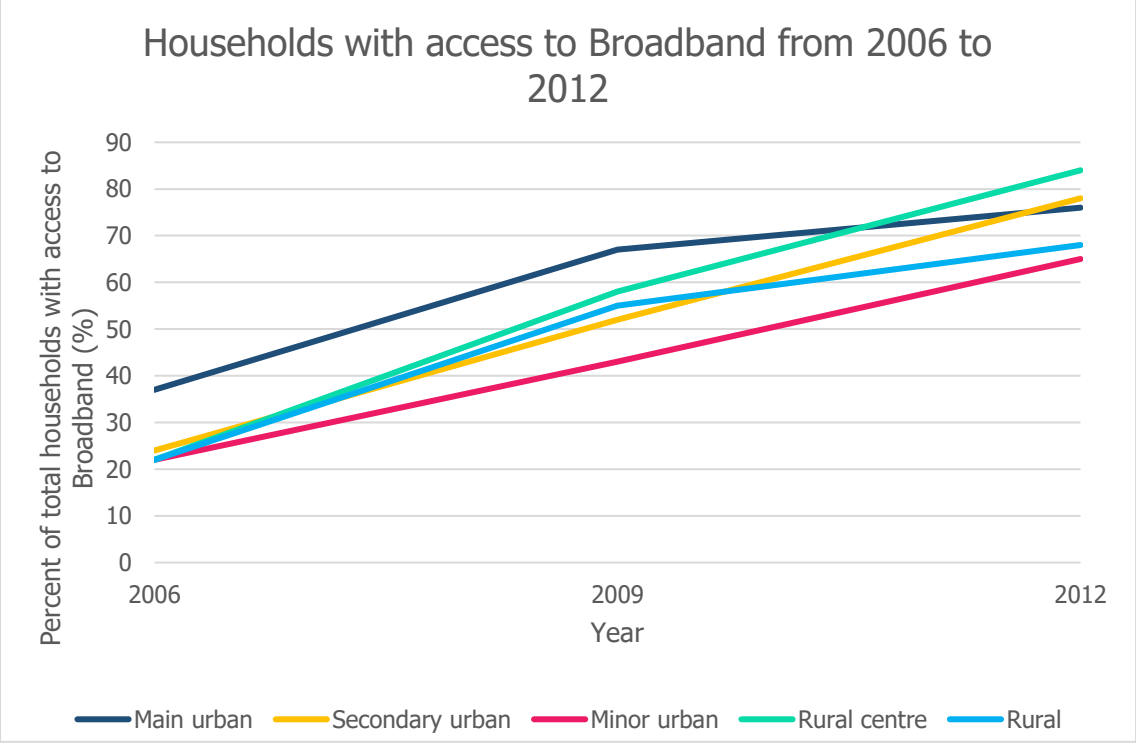


Figure 4.47 Households with access to broadband by urban/rural influence 2006 to 2012 (Statistics New Zealand, 2013a)

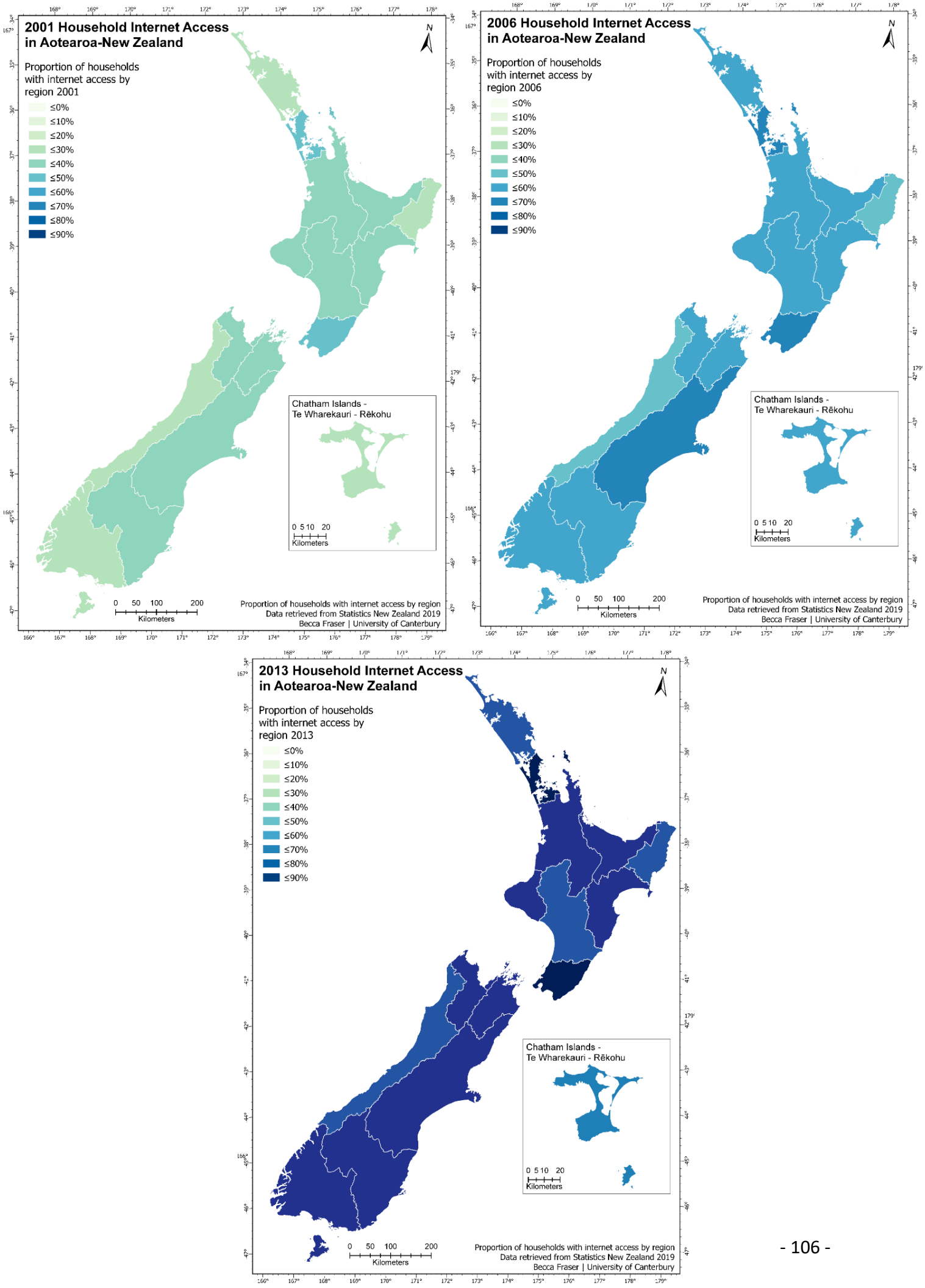


Figure 4.48 Proportion of Households with Internet Access in Aotearoa- New Zealand 2001 to 2013 (Statistics New Zealand, 2013a)

4.5.4 Limitations

Datasets that show technological change have a limited temporal spread, partly due to the nature of the data. The irrigation and broadband data has been collected from a limited number of years. Additionally the geographical resolution of this data could obscure urban and rural differences, such as access to broadband, which is likely to be better in urban centres compared to rural communities.

Primary industry Research and Development does not specify what kind of activities are taking place, so there is no way of knowing if this is related to activities that could influence rural disaster resilience.

5 DISCUSSION

5.1 Introduction

This chapter discusses and analyses the results presented in chapter five. It begins with a discussion of rural change in New Zealand, including demographic change and migration, declines in rural service provision and land use changes. The Living Standards Framework capitals are used as a lens to analyse the potential impacts these changes are likely to have on rural disaster resilience. The second section of this chapter discusses the implications of the key methodological findings of this research, which include the challenges of identifying, accessing and using research data as the basis of indicator frameworks analysis. Thirdly, a broader discussion of the impacts of rural New Zealand change on disaster resilience to date concludes with implications for the future. (Figure 5.1).

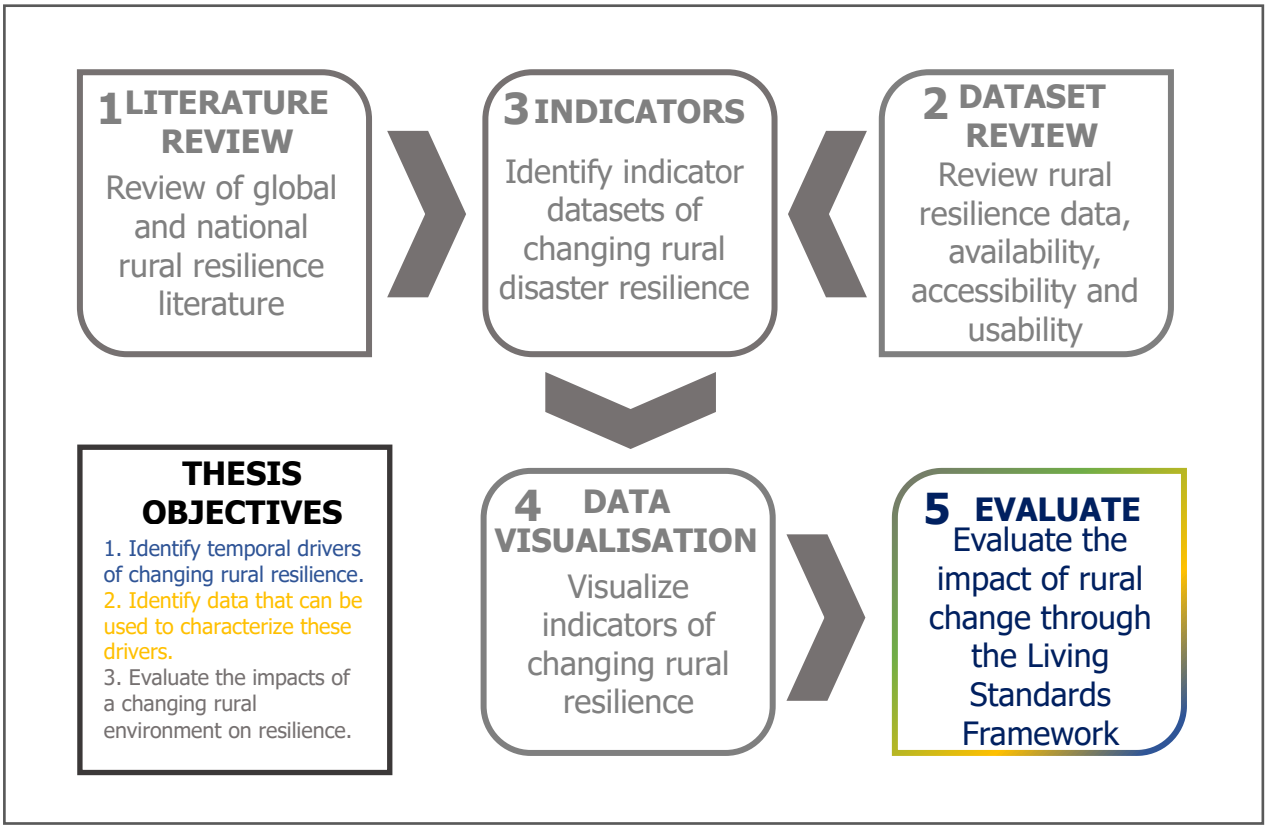


Figure 5.1 Methodology for Section Five

5.2 New Zealand Rural Change

The following sections present key results, grouped by societal, economic, environmental and technological trends. These results have been evaluated through the lens of the Living Standards Framework capitals. This is followed by recommendations for each category

5.2.1 Societal Trends

- Migration of younger populations to urban areas for work and education, and the counter movement of life-stylers and retirees is changing the demographic makeup of rural communities.
- Rural communities have older populations than those in urban areas.
- Lifestyle migrants are having a significant impact on some rural and peri-urban areas, changing the demographic composition of communities, school rolls, and demand for services.
- Land use change has also driven demographic change, when for example dairy conversions have required a migrant labour force.
- Many rural communities have borne the brunt of service rationalisation. Closures of community services like healthcare centres and schools has been widespread and reduced the physical presence of services in many rural communities.

5.2.1.1 Impacts on the Living Standards Capitals

Migration of rural populations to urban areas, and the counter flow of life-stylers have been two main drivers of changing rural demographics. Changing rural demographics and increasing population age is often pointed to as an indicator of 'decline' in rural New Zealand, as younger generations leave rural communities to take up opportunities in urban centres (Smith, 2011; Fairweather & Mulet-Marquis, 2009). Pomeroy (2019) finds that changes in the location and composition of rural populations throughout the 1970s and 1980s had more of an impact than rural depopulation per se, with flow on effects on the labour force and community life.

The movement of life-stylers out of cities and of workers moving into rural areas to work in tourism businesses has contributed to the growth of non-agricultural rural communities. These changes have had positive effects, such as a growing rates base to support investment in basic services in rural areas. However they have also contributed to the loss of productive farmland (Andrew & Dymond, 2012). Andrew and Dymond (2012) estimate that as much as 10% of New Zealand's high class productive land is currently in lifestyle block land use. Lifestyle block growth can contribute to the reinvigoration of rural communities, to growth in school rolls, and to the diversification of economic activity (Daniels, 1986; Andrew & Dymond, 2012). However, Hall (2006) notes that while population growth through lifestyle blocks can be beneficial, there are also potential issues associated with the pressure on the provision of goods and services in these areas, alongside changes to social and age structures in communities as retirees move onto lifestyle blocks.

Cohen et al. (2017) found that although there are indications that elderly populations can both contribute to and reduce the resilience of rural communities, there is a lack of strong empirical evidence about the resilience of aging populations in rural communities. Some findings have indicated that communities with older age structures may be vulnerable to the impacts of disasters (Pekovic, Seff & Rothman, 2007). However there is also evidence that the elderly can be more likely to become volunteers and advocates (Wiles and Jayasinha 2013), and in this way increase the resilience of communities during times of change through social capital (Alessa & Klinsky et al., 2008). In fact, the ability of ageing populations to contribute to community strategies for resilience through engagement and lived experience should not be understated (Maxwell, Russo and Alinovi, 2012). Cohen et al. (2017) state that more longitudinal analysis of aging populations and community disaster resilience could further explain these prevailing narratives. While this could raise questions of long term sustainability, through a disaster risk reduction lens, the increased age and institutional knowledge of these community members could be a benefit for community disaster resilience.

The impacts of the loss of services on rural disaster resilience are also important to consider as service providers like schools and post offices in rural communities serve more than just their primary function; Kearns (1991) notes them as important markers of community memory, identity and function, often serving as ad hoc community centres, making important contributions to social networks and community life (Coster, 1999; Witten et al, 2003). Joseph (2002) notes, that *"service provision is the critical link between rural settlements and rural people*" (p. 211).

The impacts of rural school closures on community capitals has been investigated by many researchers (McManus et al. 2012; Whitman et al. 2013; Oncescu, 2014; Woods, 2006; Chalmers & Joseph, 1998). In the literature, there is a growing focus on the part that schools play in community resilience and pre disaster social capital. In New Zealand, schools are important markers of community history and identity (Kearns, et al. 2009). In a study following the 2010-2011 Canterbury Earthquake sequence, Mutch (2018) found that schools play a vital role in the post disaster context. Oncescu (2013), found that rural communities with a school displayed a number of resilience attributes, in particular, close community relationships, which foster human capital. Schools play a significant role in community disaster preparation, response and recovery (Mutch, 2014: 2018; Momani & Salmi, 2012). Mutch (2018) refers to schools as community structures that both promote capital and play an important role in disaster response as a physical asset and also a community hub (Education Review Office, 2013). There is a need to better recognise the role schools play in wider community resilience (Mutch, 2018).

Like many rural service providers, health care also plays a broader role in communities. Healthcare sector restructuring from the mid- 1980s onwards resulted in the closure and withdrawal of healthcare services in many rural communities, although in places this gap was filled by community trust organisations (Kearns & Joseph, 1997). The contraction of healthcare services made it difficult to provide all but the most basic of services to rural areas, resulting in an inequitable distribution of medical care (Kearns & Joseph, 1997). The inequitable distribution of health care services between urban

and rural areas has been noted in many countries (Haynes, et al., 1999; Kearns & Joseph, 1997; Walmsley, 1978; Wilson et al., 2009). Particular challenges to healthcare provision in rural New Zealand include geographical distance, small populations, high levels of deprivation and seasonal fluctuations in population numbers (Fraser, 2006). A study of healthcare access in rural New Zealand noted that high levels of deprivation (which are a feature of some rural regions), alongside travel costs that must be incurred to access services make quality rural healthcare particularly challenging (Ministry of Health, 2002; Brabyn & Barnett, 2004). Brabyn and Barnett also note that while some rural regions are likely to be more dispersed and have longer travel times to access healthcare, it is the population characteristics such as deprivation, that play a key role in health outcomes (2004). Cohen et al (2017) note that there is a close relationship between healthcare and community resilience with many attributes of community resilience closely associated with community health (Poortinga, 2012; Chandra et al., 2010). More research to establish the links between social deprivation, rurality and disaster resilience could more clearly indicate the disaster resilience implications of rural healthcare service decline.

While the loss of services has impacted rural communities, somewhat conversely, some researchers have noted that for some communities, the fight to save their services has bolstered community social capital, perhaps contributing to better post disaster outcomes (Brown, 2003; Liu et al., 2001).

Pomeroy (2019) states that the default classification of rural and agricultural as interchangeable has resulted in past research focusing heavily on farming, with little attention to the other social and economic activities that take place in rural communities. This emphasis on agriculture also extends to policy, with the societal aspects of rural communities overlooked in favour of farming focused rural policy (Pomeroy, 2019). The notion of resilience cannot be fully measured by top down indicators that ignore the social and community aspects of resilience, such as intangible factors like cultural heritage. Therefore there is a need for more insight into the resilience of different rural perspectives beyond those discussed here (Pomeroy, 2019). Smith et al. (2012) states that for rural communities in New Zealand, societal

change has undermined their capacity to respond to hazard events. Through the lens of the LSF, the primary impacts of societal change have influenced human and social capital in rural communities. There is likely to be sub-regional geographical differences. Peri-urban areas may have experienced growth in the population and a growing rates base for community investment and services, whereas some highly rural/remote areas may have experienced population decline and an aging population structure. Additionally, it is clear that the rural environment has changed with new and growing populations such as migrant workers, lifestyle block owners and rural non-agricultural community members, but these groups are under-researched and not well represented in available data, indicating that more work is needed to fill these knowledge gaps for rural decision makers.

5.2.1.2 Recommendations

Societal change data consisting of demographic and population change data, as well as rural services data were analysed for this section. Several key recommendations have been made on the basis of these results.

- The drivers of demographic change in rural communities are highly nuanced and are closely related to factors like land use change and economic shifts. More research is needed to establish sub regional trends to better identify where changes may be taking place and the potential disaster resilience impacts.
- Service decline impacted many rural communities and potentially their human and social capital. Traditionally, the impacts of these kinds of rural changes are analysed at the community level, however further research to understand the broader impacts on the rural context could be useful for policy makers and disaster decision makers.
- Further analysis of areas where societal changes may be compounded by population deprivation or hazard impacts could reveal the links between deprivation, rurality and disaster resilience implications.

- A deeper understanding of the specific disaster resilience attributes that are impacted by these broader societal trends could guide future rural data collection and understanding of future disaster resilience.
- Further research is needed to understand the specific vulnerabilities and resilience attributes of under researched/represented rural groups, such as tourism operators and retail workers.

5.2.2 Environmental Trends

- Widespread land use change and diversification has transformed the rural environment, with notable growth seen in forestry, dairy and the wine industry, as well as a decline in sheep and beef farming.
- There is a general trend of farming intensification in New Zealand, with the advent of technologies like large scale irrigation, and a negative trend in the number of farms.
- Rural communities have faced ongoing impacts from drought conditions and other natural hazards, such as flooding and earthquakes.

5.2.2.1 Impacts on the Living Standards Capitals

Environmental changes have likely impacted the social, economic, physical and environmental capital of rural New Zealand communities. Changing environmental conditions are an important consideration for rural resilience, as environmental conditions and natural capital underpin all rural communities (Fischer et al., 2007). Long term drought conditions can erode the ability of farmers to respond to hazard impacts. In the Hurunui region, research found that extended drought conditions were exacerbated by the impacts of the 2016 Kaikōura Earthquake (Cradock-Henry et al., 2018: Stevenson et al. 2017). Whitman et al (2013) notes that farming organisations are most affected by natural hazards when the core base of production is threatened by environmental changes such as drought.

Clark, Mullen and Porteous (2011) project the amount of time spent in drought conditions in parts of the North Island and eastern New Zealand to increase by 10% by 2030 to 2050. Future impacts of climate change are also expected to result in

decreased rainfall and higher temperatures in eastern regions of New Zealand, resulting in more frequent and severe drought (Cradock-Henry et al., 2019; Kenny, 2011). Drought impacts the natural, financial and social capital of rural communities. Since this is often a slow onset, repetitive and long term hazard, drought impacts on communities are often also felt in tandem with other rural challenges. Long term financial hardship experienced by sheep and beef farmers in the Manawatu, for example, was exacerbated when surging fertiliser prices from 2005 to 2010 pushed farm resilience to its limits, compounding the impacts of a subsequent drought (Smith et al. 2012).

Environmental changes take place within a larger system, with changing natural capital influencing financial and social capital. Factors like drought can erode social capital (Smith et al. 2012). The authors noted that in one study, a major drought exacerbated feelings of isolation amongst farming communities, potentially accelerating breakdowns in social networks, suggesting that drought conditions could influence the resilience of isolated communities (Paton and Johnston, 2001; Smith et al. 2011; Smith et al. 2012). Different kinds of hazard impacts also have different impacts on resilience. Smith et al. (2012) noted that the impacts of flood and drought to the same rural community were shaped by the economic, social, and policy context and the hazards themselves. However a key difference noted between the drought disaster and the flood disaster, was that the prolonged nature of drought increased feelings of isolation and had a significant impact on social capital, with drought potentially accelerating a breakdown in social networks. In contrast, the flood disaster was widely regarded as having brought the community together and actually fostered community networks (Smith et al., 2012).

This has implications for the resilience impacts of long term environmental challenges such as drought and climate change, and the cascading effects of other hazard impacts, suggesting that a better understanding of the implications of drought on rural community disaster resilience could foster better decision and policy making. Although drought is linked to meteorological conditions, the impacts of drought are modified by environmental factors, irrigation, and broader social and economic conditions

(Botterill, 2003; Smith et al., 2012). Therefore it is likely that the impacts of drought in rural New Zealand have impacted not only natural capital, but social and economic capital. While the implications of drought on agriculture have been well documented, Smith et al. (2012) argue that the reality of repeated droughts needs to be normalised in policy and community decision making, in part, to address the resilience impacts of drought on rural businesses, families and communities.

Rural communities have been impacted by other natural hazards including flooding, severe weather impacts, earthquakes and biological hazards. Flooding is a frequent hazard in New Zealand, the Ministry for the Environment (MFE) estimates that on average, major flooding in New Zealand occurs every eight months (Ministry for the Environment, 2008). Flooding in 2004 in the Manawatu Region had major impacts on affected rural communities, with the total cost estimated at almost (USD) $400 million with damage to infrastructure, landslides, and livestock and equipment losses having a major impacts on rural communities (Smith et al. 2011). Smith et al. (2011) point to the 'hollowing out' of rural communities, through land use changes and the loss of services, as responsible for worsening the impacts of this event.

More recently, the Kaikōura-Marlborough-Hurunui Earthquake in 2016 highlighted the need to understand the changing nature of these rural communities. The 7.8 (Mw) earthquake posed a significant challenge to rural communities. Severe infrastructure damage, particularly to transport routes, and widespread landslide damage had a major impact on some areas, with it taking almost three weeks for milk collection from twenty-two dairy farms to resume (Stevenson et al. 2017). Additionally the Marlborough wine growing region, which accounts for 70% of New Zealand's wine industry suffered a loss of approximately 20% of its wine tank storage capacity (Cradock-Henry et al. 2018; Stevenson et al. 2017).

Threats from biological hazards have also impacted rural communities. The Mycoplasma Bovis (M.Bovis) cattle disease and ongoing biosecurity response eradication programme which began in 2017 has included the culling of animals on affected properties, restrictions on stock movement, and farm stand down periods

(MPI, 2020). This has had emotional, social and psychological impacts on affected communities. Future studies are taking place to investigate the psychosocial impacts of this on rural communities (Skerret, 2019).

There has been widespread land use change in the rural environment, with growth in industries like dairy and viticulture and a decline in sheep and beef farming. Smith et al. (2012) suggests that there is not a simple relationship between resilience and farming type, but that this is influenced by the nature and structure of the farm business itself. The vulnerabilities of different farming types vary over space and time, so the disaster resilience implications of this change may geographically vary. Martin (1996) notes that the use of financial strategies to improve farm resilience (such as debt management) is uniform amongst different farm types, however some farm types are more limited than others. For example, dairy farmers have a range of strategies to cope with downturns, however due to the structure of the dairy industry, they are unable to manipulate product prices, and generally less able to diversify due to the pattern of labour required in dairying, so in the case of a downturn are more likely to favour the use of financial buffers. Conversely, sheep and beef farms place a greater importance on off-farm income and diversification as resilience strategies. This indicates that a strong empirical base is needed to analyse rural disaster resilience amongst different farming types, as resilience strategies and the impacts of change differ widely (Martin, 1996).

The growth and intensification of the dairy industry has had flow on effects for rural communities. Additional infrastructure requirements including power transmission line and road upgrades have been required for dairy tankers and sheds. Significant infrastructure investment and improvement such as in rail and road links, large scale dairy conversion, as well as research and development and free trade agreements have all helped to drive the growth of the dairy industry and improved the physical and financial capital of parts of rural New Zealand (Rawlinson et al., 2013).

Significant sub-regional changes in land use suggests that more localised level analysis of 'hotspots' of rural change could reveal rural communities who may have different

disaster resilience. For example, some communities may have become heavily reliant on one industry (such as dairy) and therefore may have unrealised disaster resilience and vulnerabilities. This could be supplemented with analysis of the impacts of past disaster events such as the 2016 Kaikōura Earthquake on different rural communities (Cradock-Henry et al., 2019).

5.2.2.2 Recommendations

Environmental data including land use change, drought conditions, and agricultural practices were analysed for this section. Several key recommendations have been made on the basis of these results.

- More research is needed to understand the resilience implications of widespread agricultural change, including if intensification has resulted in some communities becoming more reliant on one farming type, and/or external market. Identifying these 'hotspots' of change could effectively direct future research and indicate where specific communities may be vulnerable. This could be supplemented with an analysis of the impacts of hazard impacts on these areas.
- Additional research is needed to better understand the links between long term drought conditions and other change, such as land use or economic change, as well as the impacts of long term drought conditions on disaster resilience.
- Significant amounts of conversion to, and intensification of, the dairy industry has taken place, and is particularly notable in regions including Canterbury and Southland. More work is needed to understand where these communities are, and what their disaster resilience is like.
- Similar to the dairy industry, the wine industry has experienced sustained growth and detailed spatial data, to identify what specific communities have experienced this growth could be useful for rural disaster decision makers.
- More research is required to explore the impacts of natural hazards on rural resilience, including both slow onset (like drought) and sudden hazards (like flood).

5.2.3 Economic Trends

- Deregulation of the economy in 1984 had sweeping impacts on the rural economy, and flow on effects for rural services and the rural environment.
- Deregulation had different geographical impacts, and was more severely felt by sheep and beef farmers, leading to things like freezing works closures which had major impacts on some rural towns and non-agricultural rural community members.
- Agriculture has decreased in its contribution to the economy from 12% in 1972 to 7% in 2018.
- Some regions, like the Queenstown-Lakes District have seen decreasing reliance on agriculture for their GDP, potentially due to the growth of tourism and urban centres.
- Wool has seen a general decline in exports between 1989 and 2019 and was overtaken by the value of wine exports in 2007. While high value dairy exports like butter and cheese have helped grow New Zealand's dairy export market.

5.2.3.1 Impact on the Living Standards Framework Capitals

In New Zealand, economic changes have likely impacted the financial, social, physical and environmental capital of rural communities. The deregulation of the rural economy in the 1980s and removal of agricultural price supports exposed many farmers to global market forces, and also impacted rural communities, for every one dollar not spent by farmers, it is estimated that another three dollars was not spent in the rural services sector. This had major impacts for some rural towns with the closure of things like meat processing plants (Walker & Bell, 1994). This not only impacted financial capital, but had major impacts on social and human capital in rural communities. Unemployment in some places was widespread, such as in Patea (South Taranaki) where almost 70% of the population lost their jobs when the freezing works in the town closed (Pomeroy, 2019; Peck, 1985). Efforts to build employment opportunities in rural areas between 1984 and 2004 resulted in the development of enterprises like Kaikōura Whale Watch tourism, generating new jobs for communities (Pomeroy, 2019; Crozier, 1997).

However regional economic differences have been well documented, with fluctuating regional dependence on agriculture as global markets have changed and major centres have grown (Nel, 2014). The significance of dairy exports to some communities, makes them particularly vulnerable to changes in the global economy. Falling global dairy prices in 2015 led to what some termed a "dairy downturn', placing pressure on communities where farmers had heavily borrowed to convert their farms, potentially impacting the economic capital of rural communities (Rawlinson et al. 2013). This indicates that further research is needed to better establish financial aspects of changing rural disaster resilience. Nel (2014) states that an awareness of economic differences can encourage resilience processes and that this requires an understanding of the prevailing trends of economic and demographic change (Martin, 2011; Pike, Dawley & Tomaney, 2010). Frieling and Warren (2018) identify financial hardship as a key indicator of changing financial capital, lowering economic growth and resilience.

Martin (1996) noted that the deregulation of the economy in 1984 altered the economic environment of New Zealand farmers, who must now deal with not only physical risk but economic risks and market uncertainty. They note that these pressures are similar to those seen in countries like Australia and the USA where the agricultural sector has become more sensitive to external forces. Smith and Montgomery (2004) state that whilst the 1984 deregulation fully exposed agriculture to global market forces, this was achieved at great cost to the environment, communities and the institutional context within which agriculture operates. Many economic decisions, such as the rationalisation of rural services have also had long term impacts on the social and human capital of rural communities.

5.2.3.2 Recommendations

Data including GDP contribution, export data and the impacts of financial deregulation were analysed for this section. Several recommendations have been made on the basis of these results.

- While the impacts of economic deregulation on agriculture is relatively clear, it is less clear what the impact was of this on rural services, and its flow on impacts on the rural economy. More research is needed to establish the non-agricultural aspects of the rural economy.
- More research is needed to better understand the relationship between rural economy and disaster resilience including the vulnerabilities of different rural groups, like tourism and retail businesses, and different farming types.

5.2.4 Technological Trends

- There has been substantial growth in the scale of irrigation, particularly in the Canterbury region, and this is likely related to large scale dairy conversion.
- An increasing amount of households have access to broadband, as well as rural schools, health centres and libraries.
- Primary industry R&D has increased between 2008 and 2018, potentially indicating investment in rural technologies for future disaster resilience.

5.2.4.1 Impacts on the Living Standards Capitals

Technological trends have influenced the social, environmental, and physical capital in rural communities. Community broadband initiatives have been linked to rural resilience (Heesen, Farrington and Skerratt, 2013; Roberts, Anderson, Skerratt & Farrington, 2017). Heesen et al. (2013) found that for two rural communities in the United Kingdom, rural broadband initiatives improved social connectivity and the ability for community members to access resources, thereby improving social capital. The development and implementation of irrigation technology has allowed conversion of vast area of land in New Zealand to dairy farming, this is particularly notable in the Canterbury region has 64% of irrigated land in New Zealand. 59% of irrigation in New Zealand is on dairy farms.

A greater reliance on rural technology could impact disaster resilience outcomes in different ways. The physical capital of lifelines infrastructure, like telecommunications towers can be inherently vulnerable to some hazards. There may be little to no redundancy in rural infrastructure systems and they may require economic investment, which can be challenging in rural communities with a small population base. However technology like irrigation also allows communities to mitigate the impacts of climatic variability. Increased broadband connectivity could improve the social capital of communities and also improve access to services like education, banking and healthcare.

Future technological trends are also an important consideration for rural resilience, innovation in agricultural practice could improve agricultural outputs. Viviano (2017) notes that agricultural technologies can reduce crop dependence on water and improve agricultural outputs. Climate change mitigation and adaptation technologies may also affect future rural resilience (Frieling & Warren, 2018). Primary industry research and development has increased between 2008 and 2018, and has potentially improved the disaster resilience of rural communities through changes in financial and environmental capital.

5.2.4.2 Recommendations

- More research is needed to understand reliance on technologies in rural communities, such as telecommunications technology, and the role this plays in disaster resilience.
- More research is needed to establish how reliant are some communities are on irrigation and what this means for rural disaster resilience
- More work is needed to establish what kind of technological adaptation is required in rural areas for the future impacts of climate change and for improving future disaster resilience.

5.3 Data Challenges

This section expands on the methodological findings of this research, in particular, the challenges and opportunities provided by the research data environment. This is followed by reflections on the utility of the use of indicator frameworks for disaster resilience research and suggestions for overcoming some gaps in this environment. Finally, a broader discussion of the impacts of rural New Zealand change on disaster resilience is provided.

5.3.1 Science Communication

A key objective of this thesis was to visualise rural change for decision makers. This process utilised core science communication concepts, including the use of technology to communicate science in an effective and engaging format (Burns, O'Connor & Stocklmayer, 2003; Illingworth, 2017). This required the identification and use of a range of research data, from many different sources. Engaging in science and risk communication is an important component of disaster risk reduction. One avenue of science communication for DRR employed in this research is geospatial visualisation. MacEachren and Kraak (2001) note that data visualisation is the key to turning data into knowledge. The challenge of inherently complex and interdisciplinary problems can be met with geospatial visualisation, which provides a fundamental method of linking diverse forms of data (MacEachren and Kraak, 2001).

The process of data visualisation is an important way to identify if there are gaps in the data and where data management and collection needs to be improved. If used in conjunction with stakeholder engagement it can also become an important part of the DRR process. Some researchers have noted that the process of data visualisation and synthesising different knowledge, such as indigenous knowledge with spatial data can help to build more constructive participatory dialogue, to guide decision making (Rosenbaum & Caulshaw, 2003; Williams & Dunn 2003). However the effectiveness of this process is dependent on the availability and quality of research data.

6.3.2 Data Availability

While this research finds that rural communities have undergone change, the spatial patterns of this change and the subsequent impacts of this on disaster resilience have remained difficult to discern, since the data required to identify drivers of rural change are not gathered or stored consistently across agencies and organisations. This issue contributes to the underutilisation of existing data for decision making in New Zealand. It is also consistent with larger problems within the research data environment (Cai & Zhu, 2015). While data is required for evidence based decision making, the quality and availability of rural datasets was a challenge to this research. This indicates that there are hurdles for rural stakeholders to identify and use available rural data, and this contributes to an information poor decision-making environment. There is a need for more consistent data approaches, such as the establishment and collection of robust rural datasets, as well as the adoption of consistent data definitions and data standards across all agencies and stakeholders. This should occur alongside a focus on effective science communication to ensure data is being used to its full potential for rural disaster resilience decision making.

5.3.2 Indicator Data

Issues of data availability and quality should be considered when undertaking rural disaster resilience research. The notion of indicator data frameworks are challenged by the complexity of the data environment. These challenges indicate that the use of indicator frameworks for resilience analysis should be approached with caution (Hinkel, 2011; Prior & Hagmann, 2014). Locating indicator data can be time and resource intensive, if the data exists. Data must also be suitable for analysis and within required parameters for effective analysis. Furthermore, community level indicator frameworks can make comparative study between communities difficult, and at the national level, a lack of robust, comparable indicator data can hinder progress.

Prior and Hagmann (2014) note that as the popularity of the term resilience has grown, so too has the development of resilience indices, employing indicator data or variables to measure different dimensions of resilience. However, they note that exploring the measurement of resilience requires measurable phenomenon, which is

challenged by the conceptual nature of the term resilience. Furthermore, Hinkel (2011) determined that while policy and governance tend to demand the use of indicators, many, if not all indicator frameworks may only be suitable for addressing local scale resilience of people, and communities in environments that can be narrowly defined. Indicating that this may not be an adequate methodology for addressing other resilience dimensions, like identifying areas of intervention and investment and monitoring adaptation (Bohringer & Jochem, 2007; Hinkel, 2011).

There is a growing body of literature questioning whether indicators can be both scientifically robust, and policy relevant (Eriksen & Kelly, 2006; Klein, 2009; Bohringer and Jochem, 2007). Some researchers note that it is unclear whether the use of indices for resilience analysis can fully capture the complexities of disaster resilience (Cutter et al. 2014; Hinkel, 2011; Prior & Hagmann, 2014). Hinkel (2011) suggest that indicators could be an example of failed science policy communication, but that this comes from confusion about what indicators can accomplish, and the inconsistent range of definitions in the field. If resilience as a concept is to be operationalised, the use of robust methodological frameworks is necessary (Miles, 2015). However if resilience research is to overcome these challenges then further research must be undertaken to determine whether indicator frameworks are always appropriate. If so, they must be accompanied by a broad commitment to universal data quality standards, alongside further work to overcome the disciplinary siloes that exist between practitioners and decision makers.

Some of these data challenges could potentially be remedied through the utilisation of policies like Sendai Framework, or the Organisation for Economic Co-operation and Development (OECD) reporting frameworks, to build robust collections of data. The Sendai Framework identifies thirty-eight indicators to measure progress against seven broad targets (UNDRR, 2017). UNDRR (2017) have also developed guidance around minimum metadata and statistics standards, as well as methodologies for indicator measurement as a part of this process. The OECD Better Life Index, upon which the Living Standards Framework wellbeing vision is based notes that risk across natural, economic, and social systems threaten wellbeing, therefore the focus must extend

from economies to the wellbeing of people and communities (OECD, 2020). The Index analyses wellbeing across eleven topics, including housing, education, civic engagement and communities. Using an established framework could overcome some of the challenges associated with the collection of research data and indicator frameworks. Utilising an existing framework also allows comparative study across a wider range of rural environments, such as between countries.

This would have to take place in conjunction with a push for better data infrastructure and management, as outlined in the NZDS. Substantial work would be required to resolve issues with the use of research data (Statistics New Zealand, 2018b). As Cai and Zhu (2015) note, issues of usability, availability, and reliability continue to hamper the efficient use of available data in a variety of applications. As shown throughout this research, the availability and quality of data was an ongoing challenge. Alongside these common data issues, better understanding of end user needs and the information requirements of rural decision makers is required. Historically, rural resilience analysis has been undertaken by disciplinary experts leading to information siloes. However the NZDS notes that a lack of translators to bridge communication gaps between data practitioners and decision makers contributes to inconsistent data practices and inefficiency (2019). The disconnect between data practitioners and decision makers suggests that some kind of knowledge 'broker' who facilitates communication between practitioners and end users could maximise the efficiency and uptake of research data. The use of knowledge brokers between practitioners and end users could improve the use of research data and also help with determining future data needs.

This research revealed that community level drivers, like drought impacts, and the closure of rural services, despite their impacts on rural disaster resilience, have not always been well translated to data. Many high-level drivers exclude different rural groups. This is compounded by the nature of rural data, which focuses heavily on agriculture. This has been noted by numerous researchers who state that rural resilience can often be characterised in a purely agricultural fashion, thus, rural vulnerabilities may be overstated with regard to environmental change and livelihood

resilience, rather than reflecting the true nature of the community (Race et al., 2010; Lockie, 2000; McManus et al., 2012; Liu et al., 2007; Gwimbi, 2009; Pomeroy, 2019). This could be caused by the overburden of agricultural rural data, in lieu of data that reflects the actual rural community.

This contributes to a rural knowledge gap in DRR, with the drivers of resilience in rural areas subsequently unclear. Pomeroy (2019) notes that default position in which the agricultural and rural concepts are interchangeable has resulted in past research focusing on farming, with little attention to the other social and economic activities that take place in rural communities. This emphasis on agriculture also extends to policy, with the societal aspects of rural communities overlooked in favour of farming focused rural policy. Pomeroy (2019) argues that this narrow focus continues today, with the Rural Communities portfolio sitting within the Ministry of Primary Industries. This drives a primary industry focused view that ignores other rural community members, such as tourism operators, local government employees and retirees. Currently there is no agency specifically mandated to foster rural development by placing economic outcomes alongside social and environmental outcomes. This fragmentation in rural governance results in a fragmentation of rural data. The development of a rural agency that addresses every aspect of rural New Zealand communities, could foster better rural policy and decision making and contribute to this rural knowledge gap (Pomeroy, 2019). Additionally, this could more effectively bring together rural data and address the siloed nature of rural research for more informed decision making.

The development of a rural data dashboard, with rural indicator datasets, could also meet this challenge. A dashboard is a tool for information management that visually tracks, and presents data, usually focused on a particular subject (Smith, 2013). Dashboards are a powerful visual tool for communicating information (Few, 2006). Smith (2013) states that effective dashboards are often designed as monitoring tools, with the ability to visually communicate large amounts of information to a range of audiences. Many dashboards have data analysis capabilities inbuilt and can integrate data from many different sources. Dashboard resources are already in use across

government departments such as the MBIE Regional Activity Dashboard (Figure 5.2). Other examples include the New Zealand Trade Dashboard (Statistics New Zealand), Urban Development Capacity Dashboard (Ministry of Housing and Urban Development), Tourism Dashboard (MBIE) and the New Zealand Industry Sectors Dashboard (MBIE). New Zealand Treasury also hosts a Living Standards Framework dashboard which analyses data through the lens of the wellbeing capitals. This indicates that capability already exists within government departments for the development of these kinds of resources. A cohesive rural data dashboard should acknowledge all aspects of rural communities, such as the social and cultural aspects of communities, and be well maintained with robust, relevant, longitudinal datasets. A rural data dashboard could also provide the basis from which to implement standard rural definitions and data collection.The improved accessibility of rural data could lead to more informed decision making for disaster resilience.

Figure 5.2 Regional Economic Activity dashboard (MBIE, 2020)

5.3.3 Recommendations:

This section outlines rural data gaps, and provides recommendations for future data collection.

- Financial data about 'non-agricultural rural', such as rural tourism or retail workers is difficult to find, so difficult to establish resilience change. Future work to build this data could be useful for rural disaster decision makers.
- Land use change is shifting community dependence to different kinds of livelihoods, but spatial data about communities who have experienced this change is difficult to locate. Indicating a need for the identification of change 'hotspots' in rural New Zealand.
- Future work to establish additional data about under-researched communities like migrant workers, lifestyle block owners and non-agricultural community members is vital for rural decision makers. More spatial analysis could also indicate where these groups are and how they need to be incorporated into future disaster planning and management.
- Visualising community service changes like school closures is time intensive, and required extensive research to identify locations and/or functions of community buildings, this is compounded by the fact that many historical changes are not digitised so are difficult to translate to other formats and largely inaccessible for many researchers. However this information is important as the long term impacts of decisions like service rationalisation should be taken into account when seeking to engage with rural stakeholders, particularly from a governance standpoint.
- Despite rural medical centres serving almost 15% of the population, there is a relative lack of data about rural medical care, challenging effective rural health policy (Williams et al. 2010; Fraser, 2006). This should be addressed to better identify where access to healthcare services has impacted community disaster resilience.
- The impacts of drought, particularly long term and repeat drought conditions are difficult to capture in any dataset at a higher resolution than the regional

level or in a temporal format, meaning resilience impacts of drought are difficult to capture. Future research is needed to establish robust long term drought datasets from the community to the national level to enable ongoing, comparable analysis.

Underscoring these recommendations is that better data practices and infrastructure may be required to improve the availability and accessibility of rural data alongside data collection itself (Cai & Zhu, 2015). Some of these recommendations could be implemented using existing resources and expertise, such as improving the collection of certain types of data, like rural health data, and should/could be routinely done by government agencies. Other recommendations would require system or intergenerational change and would not be as simple to implement. This includes the need for better and more coordinated data practices, and consistent data definitions across government departments and other sectors (such as the definition of 'rural'). However this does not mean it shouldn't be done, the use of data for informed decision making is imperative to address changing rural disaster resilience and policy making. Addressing these issues and improving the use of research data for rural disaster decision making could also provide lessons for addressing these gaps in other DRR research. Additionally, the NZDS has begun to address some of these gaps, and this framework could be used to build any future rural data standards for implementation.

5.4 Evaluating the Impacts of Rural Change

The results of this research reveal that rural communities in New Zealand have undergone significant change in the past 50 years, resulting in a transformed rural landscape. Much of this change has been driven by large scale, exogenous forces, such as policy decisions, and global market forces. These changes have had long term, multi-dimensional impacts on rural communities and impacted their disaster resilience. Key indicators of this change include; migration and associated changing demographics, land use changes such as growth in dairying and viticulture, population growth in peri-urban areas, the proliferation of technology like irrigation and broadband, the loss of rural services like schools and medical centres, and the impacts of natural hazards like flood, drought, and earthquakes.

An analysis of these changes through the lens of the Living Standards Framework indicates that the social and economic capital of rural communities has been significantly impacted. Social and economic policy reforms experienced by rural communities in New Zealand are a causative factor in the loss of social capital, particularly through the loss of rural services and employment (Ashton & Thorns, 2007; Pomeroy & Newell, 2011). The range of factors that influence social and economic capital is highly complex, including factors like demographic change, population change, and economic change (Cutter et al. 2016; Vallance & Carlton, 2015; Fraser, 2006; Statistics NZ, 2017). In New Zealand, changing financial capital for farmers in rural communities in the 1980s had flow on impacts for rural services (Walker & Bell, 1994). Zander et al. (2017) note that strong financial capital is vital, as those with financial capital can invest in resilience activities.

Alongside this, the natural capital of rural communities has faced challenges from changing rural conditions. Exposure to natural hazards has significant impacts on, and implications for rural communities, with hazards including floods, snowstorms, drought and earthquake all challenging rural disaster resilience, alongside the potential future impacts of climate change (Stroombergen et al. 2006; Lawrence et al. 2013; Cradock-Henry et al. 2018; Spector et al. 2018). Additionally there has been widespread shifts in land use and agricultural practices, with different resilience implications for different groups. Notable changes include agricultural diversification to farming types like viticulture and dairy, alongside a decline in sheep and beef farming, and intensification through the use of technology like irrigation.

Changing physical capital, including the maintenance and renewal of infrastructure networks and buildings, natural hazard and extreme weather impacts, and economic change has also impacted rural communities. Zander et al. (2017), note that technology and infrastructure can boost physical capital and improve resilience. They note that government investment in things like infrastructure, can also improve financial and social capital. The physical capital of rural communities in some places has been underinvested in due to declining population and rates bases, while in other places, physical capital has been improved due to land use change such as dairy conversion and lifestyle block migrant movement.

The use of the Living Standards Framework is one way of assessing changing community resilience, in a New Zealand context. The use of a capitals focused framework is a useful lens for assessing community resilience because change happens across systems of capitals that make up communities and build upon each other to increase or decrease resilience (Emery & Flora, 2006; Stevenson et al., 2019). For example, a decrease in financial capital for farming businesses may also impact natural capital as environmental maintenance (like fertilising land) is unable to take place (Smith et al. 2012). This approach acknowledges the many dynamic drivers of resilience in rural communities, highlighting that capitals based approaches could be useful for assessing future risk and resilience (Stevenson & Kay, 2019). The impacts of these changes should be taken into consideration for future rural research and engagement, to ensure that rural DRR and policy making more effectively meets the needs of rural communities.

6 SUMMARY

The purpose of this thesis was to assess the impacts of dynamic, temporal change on the resilience of rural communities in New Zealand. The aim of this was to provide a clearer understanding of the extent and impacts of change in rural New Zealand in multiple dimensions, to improve understanding of the drivers of disaster resilience in rural New Zealand. To achieve the research objectives, a review of rural literature, and New Zealand data was undertaken to gather a suite of rural disaster resilience indicator datasets. These indicators were visualised, primarily using geospatial analysis. The results were then discussed through the lens of the Living Standards Framework, to quantify the potential impacts of this change on resilience.

A review of global and New Zealand based literature identified potential resilience drivers, including demographic change, land use changes, technological developments and economic trends. The literature review produced four categories of rural change; societal, economic, environmental and technological. Following this, a review of the New Zealand data landscape was undertaken to understand challenges to the use of research data in New Zealand and data quality parameters as well as available data for analysis.

Data quality parameters were established to guide the selection of indicator datasets, including factors like relevance, usability and reliability (such as if the data had a suitable geographic and temporal range). The results of this review indicated that data use is hindered by problems of availability, accessibility and disciplinary siloes which contribute to a complex research data landscape. The literature and data reviews enabled the collection of indicator datasets to analyse rural New Zealand change. Indicator datasets were visualised using a range of techniques, aiming to translate rural data to usable knowledge (MacEachren & Kraak, 2013).

This revealed that rural communities in New Zealand have undergone significant change in the past 50 years. Key changes have included demographic shifts, land use

change, and long term, multi-dimensional impacts from economy and policy decisions like service rationalisation, such as the closure of schools and medical centres.

Data reflecting the changes experienced by rural New Zealand is not currently readily available or accessible to rural decision makers. This leads to an information poor decision making environment. Currently, the DRR governance framework and rural data collection in New Zealand does not clearly address the changing nature of rural communities far beyond rural agricultural change. Therefore, there is a lack of urgency to understand and track resilience drivers in rural areas. Additionally, future rural DRR activities should take into account the lived experiences of rural communities, and the scale of change rural areas have undergone. Furthermore, there are aspects of rural communities that are not effectively captured in data (such as those on lifestyle blocks, retirees and migrants), as well as the impacts of factors like drought on rural disaster resilience. Therefore current rural decision making from the government to the community level does not serve all of New Zealand's rural population. There is a need for more work towards building better, more robust datasets which align with the needs of rural stakeholders. Alongside this is the need for the adoption of consistent approaches to the definitions and collection of rural data across government agencies and the private sector.

The use of indicator data to analyse community resilience should be approached with caution. Consistent and widespread issues of data collation and collection, availability and accessibility are unlikely to ever be fully resolved in a way that allows for comparative (and therefore effective) indicator studies between rural communities (with the exception of indicators within reporting frameworks like The Sendai Framework for Disaster Risk Reduction). The siloed nature of the research environment in New Zealand and internationally also contributes to these issues. The use of knowledge 'brokers' to overcome disciplinary siloes and engage with both data practitioners and stakeholders could improve data utilisation for decision making. This could also potentially overcome some of the challenges of identifying and using robust datasets. The creation of a rural data dashboard could also address some of these issues, and be a centralised base for the analysis and collection of New Zealand rural

data, with a social and environmental focus alongside agriculture. A rural data dashboard could also provide the basis from which to implement standard rural definitions and data collection.

The methodological findings of this thesis reveal that the availability and quality of data for rural decision makers is challenged by the nature of rural research and data collection in New Zealand. Additionally, available data does not currently reflect the true nature of New Zealand rural communities. However the rural changes explored in this research underscore the importance of this data for rural decision makers. The findings of this research provide lessons for exploring future rural disaster resilience and outline the need to develop more effective systems for utilising, collecting and analysing research data, alongside addressing the changing nature of rural New Zealand to improve future rural policy and disaster decision making.

6.1 Future Work

I. Future stakeholder engagement should be utilised to evaluate the suitability of these resources and data for decision making. This should be done through both a science communication lens, and to establish what data rural decision makers require/find most useful.

II. A case study should be used to validate the findings of this thesis. An in depth case study of community disaster resilience, evaluating the trends discussed in this research in the context of hazard impacts would provide more context to rural disaster resilience impacts at the national level.

III. The identification of rural areas that have undergone extensive/widespread change should be used to identify future priority areas of focus for data collection, and rural disaster resilience research.

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APPENDICES

APPENDIX A

A.1 Disaster Risk Reduction Terminology

Disasters are defined as a *"serious disruption of the functioning of a community or society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity"* (Prevention Web, 2009).

Disaster Risk is a function of three components: hazard, exposure and vulnerability (GFDRR, 2016). These are essential components of disaster risk, a foundational aspect of DRR and dynamically fluctuate over time, both naturally and through human activity (UNDRR, 2017). Changes in these components influence other components and contribute to changes in overall risk (GFDRR, 2016).

Hazard is the intensity and probability of a phenomenon occurring. Although they can be manmade, the term is predominantly associated with natural hazards, the result of natural processes (Prevention Web, 2016; UNDRR 2017). Hazards can be environmental, geological, and even hydro-meteorological; such as seismic activity, volcanic activity, and extreme weather events, as well as potential future impacts of climate change (Prevention Web, 2016; Glavovic, Saunders & Becker, 2010).

Exposure is the location of assets and people that make them susceptible to impacts from hazards. Exposure, and its impact on disaster outcomes, can be driven by changing factors such as population trends, socioeconomic change and land use planning (GFDRR, 2016).

Vulnerability is the susceptibility of exposed elements to a hazard, such as the physical vulnerability of different types of buildings in an earthquake event, but also can refer socioeconomic vulnerability, factors that influence a community's ability to respond, cope with and recover from a disaster event (GFDRR, 2016; Guha-Sapir,

2015; Prevention Web, 2016). Vulnerability is a complex component of disaster risk and is dependent on many different factors. Vulnerability as a concept can differ in meaning depending on who is using it; changing social, physical, economic and political contexts are all aspects of vulnerability (Allen, 2006).

Disaster Risk Reduction (DRR) aims to facilitate better outcomes of the impacts of hazards on communities including, a reduction in disaster risk and losses in *"lives, livelihoods and health and in economic, physical, social, cultural and environmental assets of persons, business, communities and countries"* (UNDRR 2017). DRR aims to manage residual risk, reduce existing risk and prevent new disaster risk with the ultimate goal to *"strengthen economic, social, health and environmental resilience"* (UNDRR 2017).

Resilience is the ability of a community exposed to hazards to *"resist, absorb, adapt to and recover from the effects of a hazard in a timely and efficient manner*" (UNDRR 2017). Improving resilience is a key aspect of DRR when aiming to improve future disaster outcomes.

Disaster Risk Management (DRM) aims to reduce some or all of the components of risk to reduce overall disaster risk and improve resilience. DRM implementation sets out specific goals and objectives for reducing disaster risk (UNDRR 2017). It is highly contextual and can be implemented through different policies and strategies, and stakeholder engagement with communities. Globally, DRM is guided by the Sendai Framework for Disaster Risk Reduction 2015-2030.

The Sendai Framework for Disaster Risk Reduction 2015 - 2030 is a framework developed by the United Nations Office for Disaster Risk Reduction (UNDRR), predated by the Hyogo Framework 2005 - 2015. The Framework aims to coordinate global disaster risk reduction efforts by fostering coherence in reducing risk, improving resilience and improving the outcomes of hazard impacts on communities. Four main priorities underline the Sendai Framework (2015);

1. *Understanding disaster risk*

2. *Strengthening governance to manage disaster risk*
3. *Investing in disaster risk reduction for resilience*
4. *Enhancing preparedness for effective response and to build back better in recovery*

The Sendai Framework recognises that governments play a primary role in disaster risk reduction, and that this responsibility is shared with researchers, local governments, communities, and the private sector (Pica, 2018). To achieve this, it emphasises a move toward addressing the exposure, vulnerability, capacity and resilience of communities (Aitsi-Selmi et al., 2015).

A.2 Research Data Terminology

Dimensions of data quality:

Availability: Data availability refers to whether a data interface is provided, and whether data is public or easy to purchase within a given timeframe, data sets are regularly updated (Cai & Zhu, 2015)**.**

Usability: data comes from disciplinary experts and is credible, data is regularly audited, and exists in a range of acceptable or known values (Cai & Zhu, 2015).

Reliability: Accurate data that reflects the true state of the source and avoids ambiguity, processed data is consistent and verifiable, data format is consistent and with content and structural integrity. Dataset is complete and not missing components that will impact accuracy and integrity (Cai & Zhu, 2015).

Relevance: data retrieved meets end user needs.

Presentation: Clear and understandable format and content, data classification, description and coding meeting specifications and simple to understand (Cai & Zhu, 2015).

Metadata: Metadata is data that provides information about other datasets, a summary of the basic information about a dataset that makes working with and finding data easier (Hare, 2016).

A.3 Statistics New Zealand Terminology

Statistics New Zealand: Statistics New Zealand is the government's official data agency and holds a wealth of information including population, economy and societal data collected through censuses and surveys. More detailed information about these definitions is available from Statistics New Zealand, *Statistical Standard for Geographic Areas* report (2017a). 1992 Standard Area Classifications are detailed below:

Rural: Under the 1992 Standard Area Classifications, Statistics New Zealand defined rural areas as those not specifically designated urban. An experimental classification which categorised rural areas with regard to the proportion of the population that travelled to an urban area for work aimed to examine rural areas in more detail. (Fraser, 2006). The classification system has three urban and four rural categories (Statistics New Zealand, 2017a):

1. *Main urban areas:*
2. *Satellite urban areas:*
3. *Independent urban areas*
4. *Rural areas with high urban influence*
5. *Rural areas with moderate urban influence*
6. *Rural areas with low urban influence*
7. *Highly rural/remote areas*

Territorial Authority (TA): Geographic area defined as either a district or city council under the Local Government Act 2002. New Zealand has 67 territorial authorities. When TA boundaries were defined in 1989, considerable weight was given to 'communities of interest' with both size and components of the community considered (Statistics New Zealand, 2017a)..

Regional Council (RC): Geographic Area defined in 1989, boundaries of regions conform as closely as possible to water catchments. Regional councils cover every territorial authority except Chatham Islands territorial authority (Statistics New Zealand, 2017a).

Area Unit (AU): Aggregated areas of meshblocks. Non-administrative geographic area definitions, larger than meshblocks but smaller than territorial authorities. Normally have a population of between 3000 and 5000 people (Statistics New Zealand, 2017a).

District: district council governed territorial authority area. Generally serve a combination of urban and rural communities (Statistics New Zealand, 2017a).

Meshblock (MB): The smallest geographic unit used by Statistics New Zealand, aggregated to build larger geographic areas. Vary in size from large areas of rural land to small city blocks (Statistics New Zealand, 2017a).

Urban Area: contains main, secondary and minor urban geographical areas (Statistics New Zealand, 2017a).

Rural centre: no legal or administrative status but are geographic statistical units aggregated from area units. Established in 1989, generally have a population between 300 and 999 people (Statistics New Zealand, 2017a).

Rural Area: areas of New Zealand not designated 'urban'. This includes rural centres, islands, and inlets, as well as inland and oceanic waters (Statistics New Zealand, 2017a).

In 2018, the 1992 Standard Area Classifications were replaced by the 2018 Statistical standard for geographic areas. The new output geographies are defined below:

Statistical Area 1 (SA1): The SA1 geography was developed for the 2018 Census, they are non-administrative and are designed to provide a higher level of detail about population characteristics than meshblock level. Generally derived from one or more meshblocks with an ideal size of between 100 and 200 residents (a small proportion contain more than 500 residents). SA1's are defined as either rural, urban, or water (Statistics New Zealand, 2017a).

Statistical Area 2 (SA2): SA2 area geographies replaced Area Units, conceptually similar but boundaries and names have changed to reflect changing population and land use patterns. The aim of SA2 geographies is to capture similar types of areas and communities that interact economically and socially, such as farmland or high density urban areas. Generally have a population size of between 1000 to 4000 residents, however in more rural areas there may be less than 1000 residents. SA2's have also been defined in urban and industrial areas to incorporate commercial, retail and industrial activity, to be more useful for analysing labour patterns and business demographics (Statistics New Zealand, 2017a).

Urban/Rural: The geographic urban/rural classification delineates areas that share common characteristics. **Urban areas, rural settlements** and **other rural areas**: Urban represents densely populated urban areas, rural settlements and other rural areas are those not defined as urban (Statistics New Zealand, 2017a).

Rural settlements are generally comprised of 200 – 1000 residents or at least 40 dwellings, they also contain a minimum of one community building, such as a store, or school. This output geography includes settlements previously defined as rural centres (Statistics New Zealand, 2017a).
Other rural areas include areas located outside urban areas and rural settlements and include agricultural land as well as national parks (Statistics New Zealand, 2017a).

Bodies of water are identified separately. Meshblocks, Regional Council and Territorial Authority Geographies remain the same.

Resident population: Statistics New Zealand defines **resident population** as *"an estimate of all people who usually live in an area at a given date"*. **Census usually resident population** is defined as *"a count of all people enumerated by census who usually live in that area and were present in New Zealand on census night"* (p.24, Statistics New Zealand, 2017a).

Australian and New Zealand Standard Industrial Classification (ANZSIC): the ANZSIC classification was developed in the 1990s to reflect the Australian and New Zealand industries, and allow for comparability between the two (Statistics New Zealand, 2017a).

Statistics New Zealand Data Limitations

Changes to statistical geographies are made continuously. Annual updates are released each year and may reflect adjustments to geography boundaries and changes in population and communities (Statistics New Zealand, 2017a).

Statistics New Zealand has used 'random rounding' since the 1981 census, by rounding statistics to base three, allowing the release of data without compromising privacy. The effect of this on accuracy is insignificant (Statistics New Zealand, 2017a).

Until 1945, separate censuses took place for the non-Maori and Maori population, so overall population numbers may be undercounted (RCG, 2018). Additionally, while with few exceptions, censuses have been carried out every five years since 1881; notable cancellations and postponements of the census include the Great Depression, World Wars One and Two, and the Canterbury Earthquake Sequence (2011 census postponed to 2013) (RCG, 2018).

In 2018, Statistics New Zealand launched the 'Digital First Census' in a move towards an online census process. Whilst it was reported that the quality of data was very high, it also saw an increase in non-respondents, with the response rate declining from 92% in 2013, to 83% in 2018. The 2018 census also saw the use of 'imputation' – assigning a value where a response was missing or unidentifiable, a statistical

process intended to avoid skewed results due to a lack of data (Kukutai & Cormack, 2018).

The Digital First Census faced some issues with accessibility, particularly for the elderly and disabled, and some have raised concerns that some groups such as Maori were undercounted (Kukutai & Cormack, 2018). As census data is used to direct and prioritise government services and funding this should be kept in mind.

APPENDIX B:

B.1: Data Sources

Table B.1 Data Sources Identified in the data review process

Source Organisation	Key data themes
Data.govt.nz	Guide to government held datasets within ministries.
Department of Conservation	• Pest distribution • Ecological regions • Public conservation areas and reserves • DOC tracks, huts, campsites
Department of Internal Affairs	Official Information Act Requests • Local Authority Election Statistics • New Zealand Public Sector Websites • Lottery Grants Board Recipients • New Zealand Gazette • Ministers Expenses • New Zealand Libraries
Environmental Health Indicators New Zealand	• Air quality • Water • Hazardous substances • Climate change data • Energy use • Population vulnerability • Alcohol related harm • Animal and human health • UV exposure • Border Health
Figure.co.nz	Visualised Statistics New Zealand datasets • Figures • Charts • Maps
GNS Science	• Natural Hazards Databases

	• Geoscience data repository • Palaeontology & Stratigraphy • Mapping Resources
KiwiRail	• Railway Network • Level Crossings • Bridges • Tunnels
Koordinates	• Topographic • Hydrographic • Cadastral • National imagery • National Datasets (e.g. State Highways, River Centrelines, Land Parcels)
Land Information New Zealand (LINZ)	• Topographic • Hydrographic • Cadastral • National imagery
Manaaki Whenua – Landcare Research	• Insect Ecology • New Zealand Birds • National Vegetation • Plant Names database • Research papers
Ministry for Primary Industries	• Agriculture Compliance programmes • Forestry • Agriculture production statistics • Horticulture • Livestock slaughter statistics • Fisheries statistics • Greenhouse gas reporting • Situation & Outlook for Primary Industries reporting • Adverse events declarations

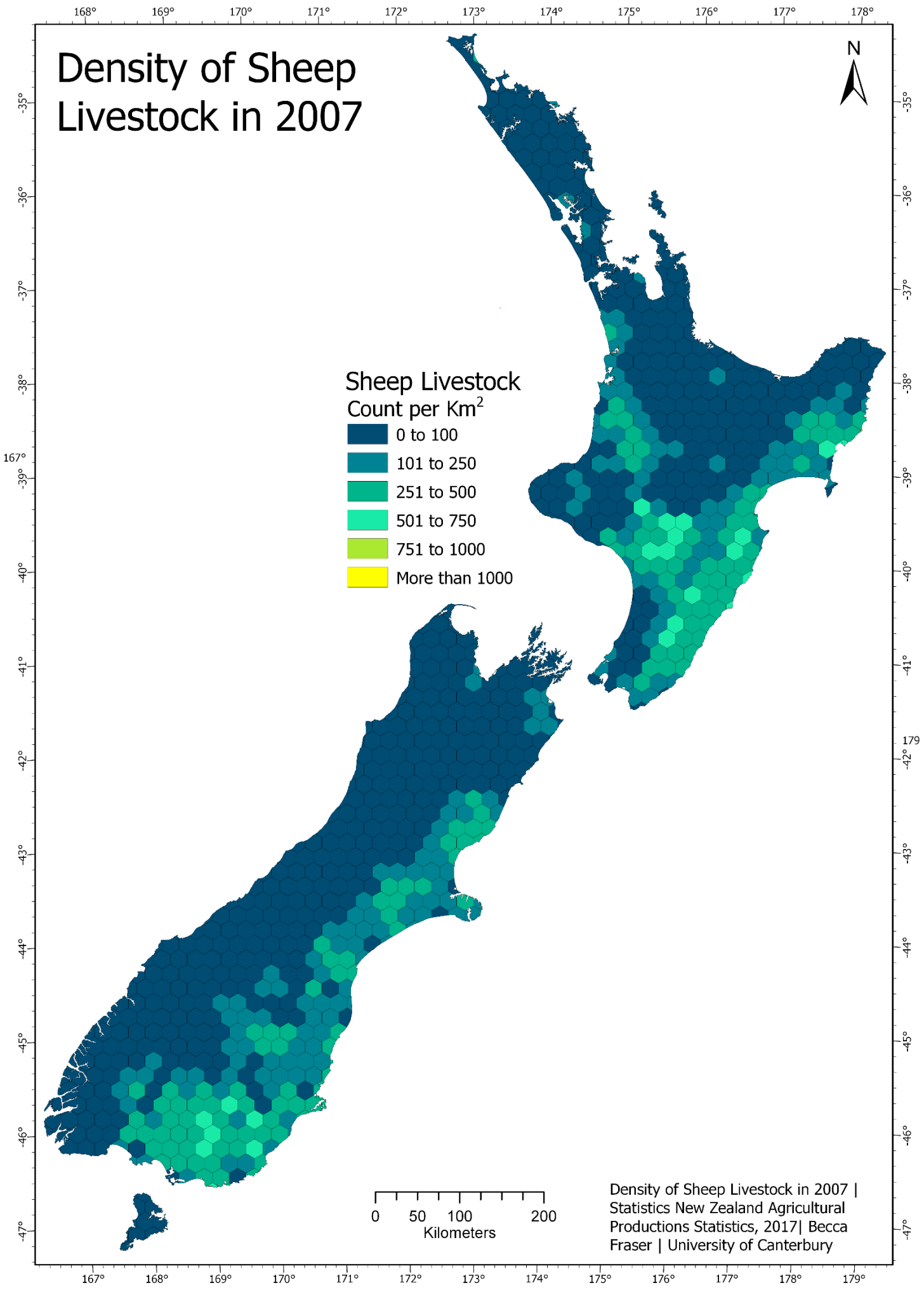
Ministry for the Environment	• Land Use Capability Maps (LUCAS) • Conservation Data • Ground and Fresh Water • River Catchments • Climate and Atmosphere • Marine Environments • Satellite Imagery
Ministry of Business, Innovation and Employment (MBIE)	• Regional Economic Activity Dashboard • Energy Statistics • Tourism Dashboard • Labour Market Dashboard • New Zealand Sectors Dashboard • Territorial Authority GDP • Migration Trends • Research Reports
Ministry of Education	• School Closures • Schooling Statistics • Tertiary Education Statistics • Early Childhood Education • Maori Education
Ministry of Health	• Health Statistics • Mortality and demographic data • Environmental health • Health expenditure • Population Deprivation • Hospital closures
Ministry of Housing	• Housing affordability measure • Rental bond data • Housing market indicators
Ministry of Social Development	• Benefit Fact sheets • Social Housing

	• Regional Housing Data • Studylink Statistics
National Institute of Water and Atmospheric Research (NIWA)	• National Climate Database • Drought Indicator Index • Historical annual climate data
National Library of New Zealand	Historical and contemporary maps, charts, and publications.
New Zealand Transport Authority (NZTA)	• Road Centrelines • Motor Vehicle Register • Crash Analysis Data • State Highway Data
New Zealand Treasury	• Budget Data • Monthly Economic Indicators • Fiscal Time Series
OECD Data Library	• Population • Education • GDP • Tax • Income inequality • CO2 emissions • Household Debt • Unemployment • Agriculture
Reserve Bank of New Zealand	• Exchange and Interest Rates • Lending Statistics • Registered Banks • Insurance Statistics • Economic Indicators • Labour Market • Housing • GDP statistics

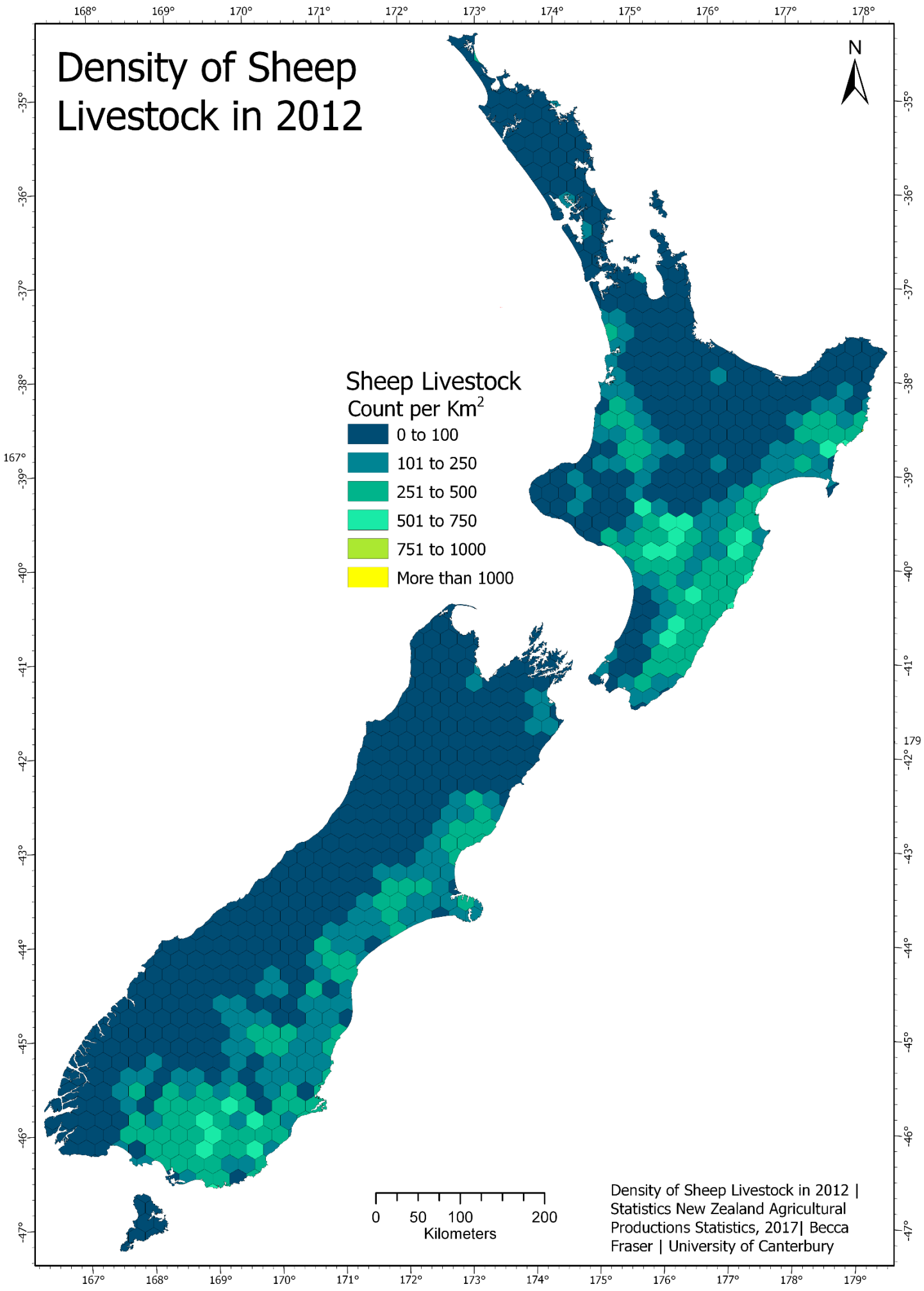
	• Population and Migration • Inflation
Statistics New Zealand	• Economy • Population • Society • Census data
World Bank	• More than 8,000 time series datasets • 3,000 census and administrative datasets • 751 geospatial datasets

APPENDIX C:

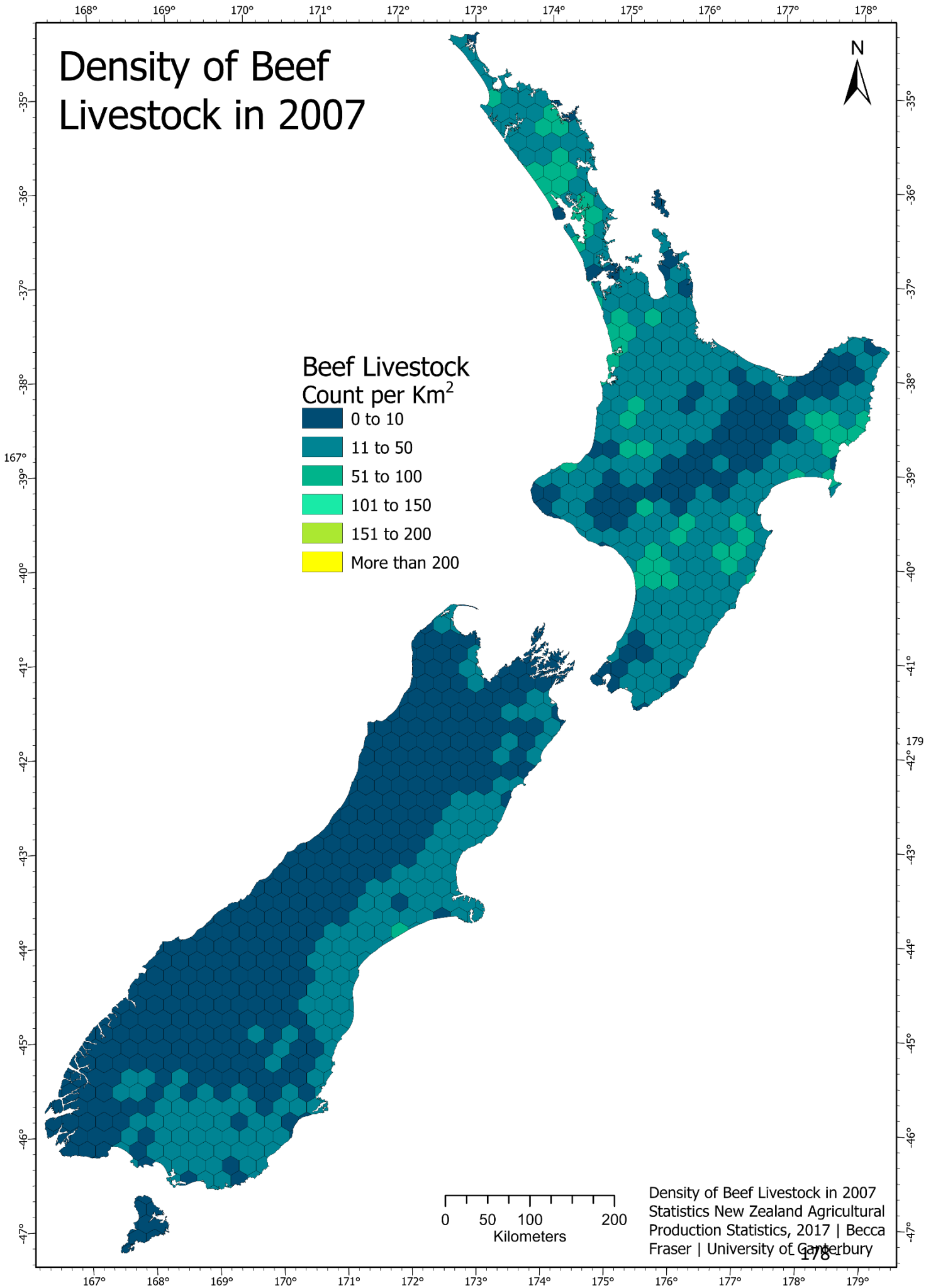
C.1 Supplementary Maps



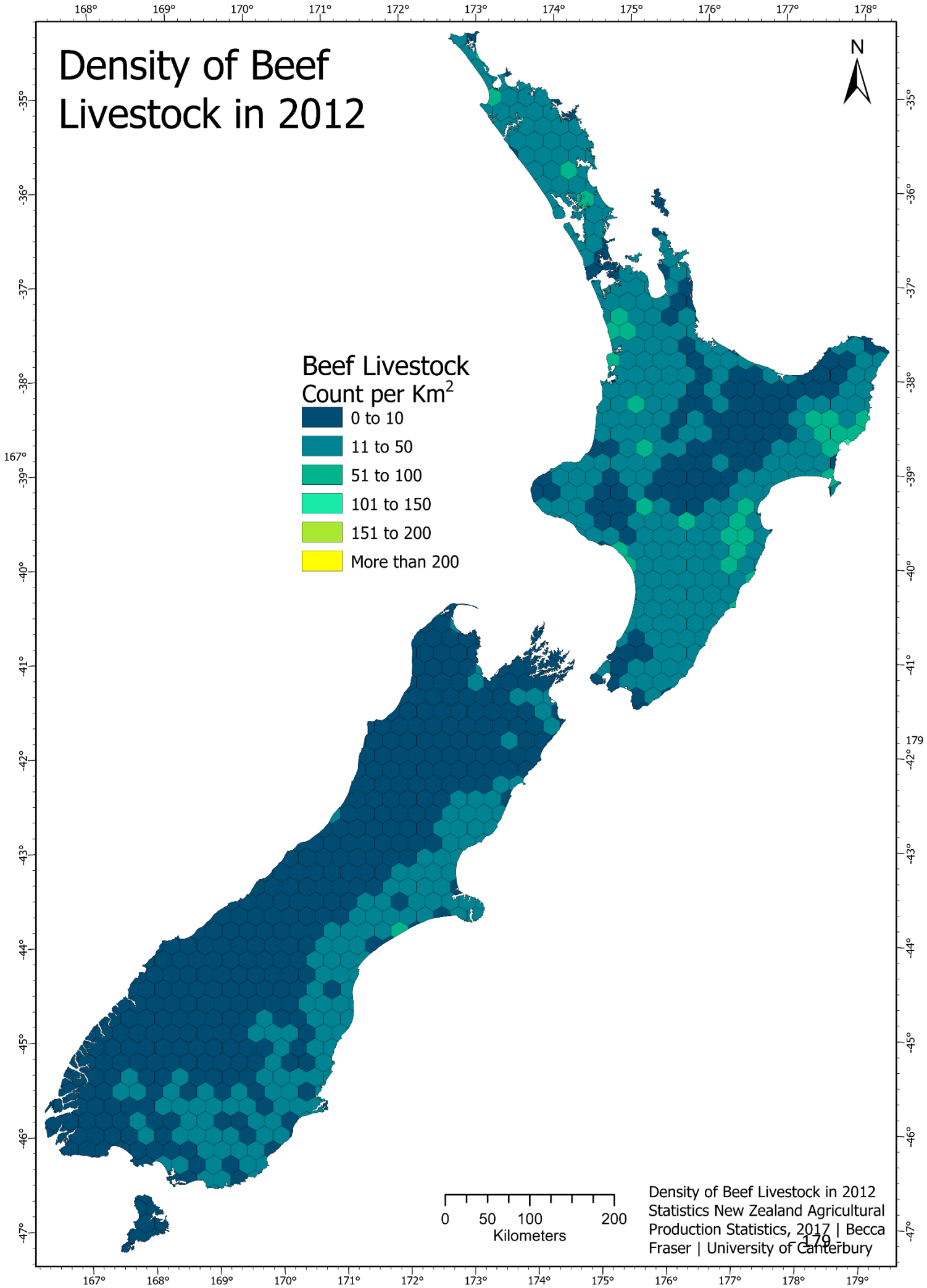
Appendix Figure C.1. Density of Sheep Livestock in 2007 (Statistics New Zealand, 2018d)



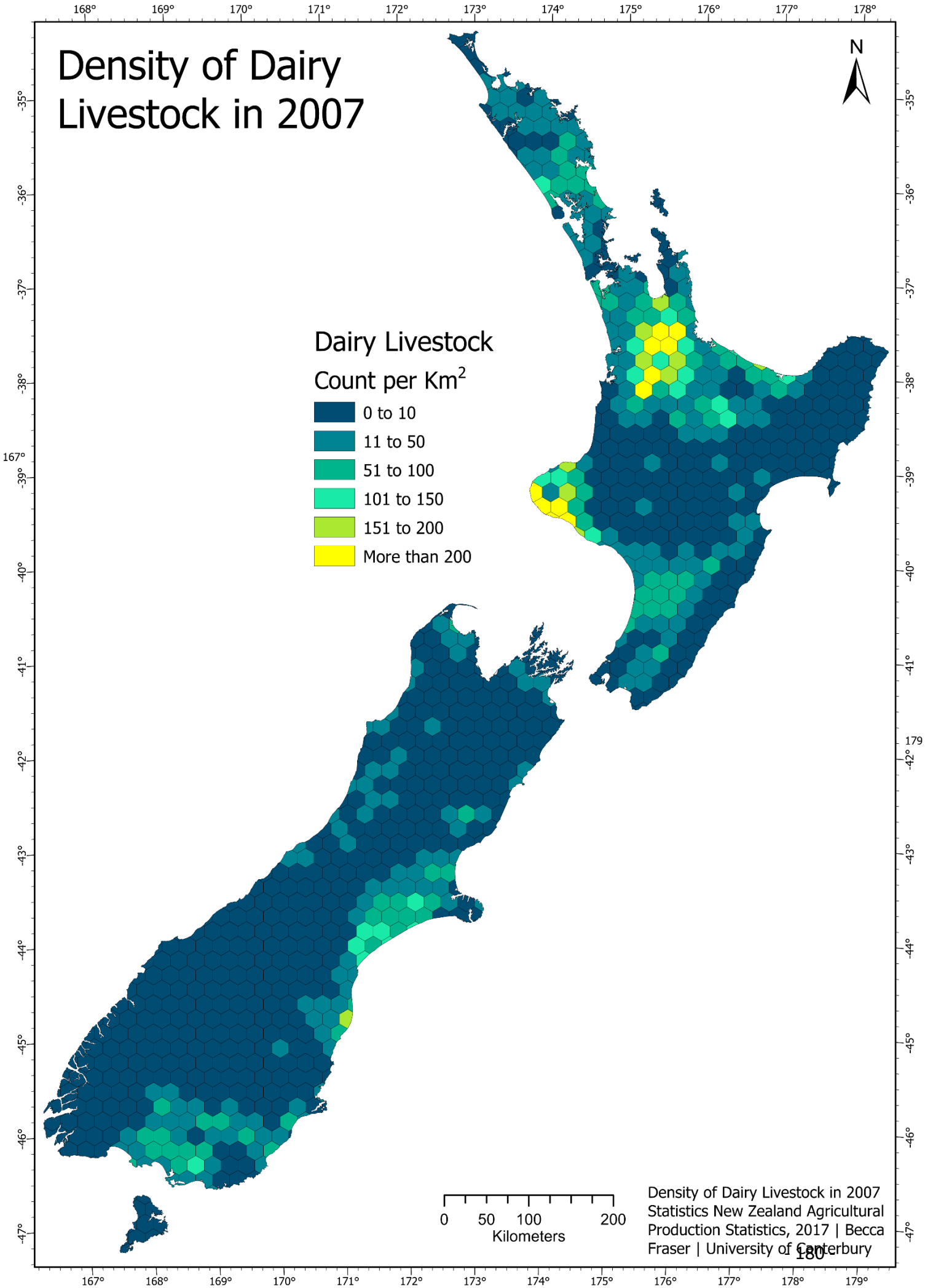
Appendix Figure C.2. Density of Sheep Livestock in 2012 (Statistics New Zealand, 2018d)



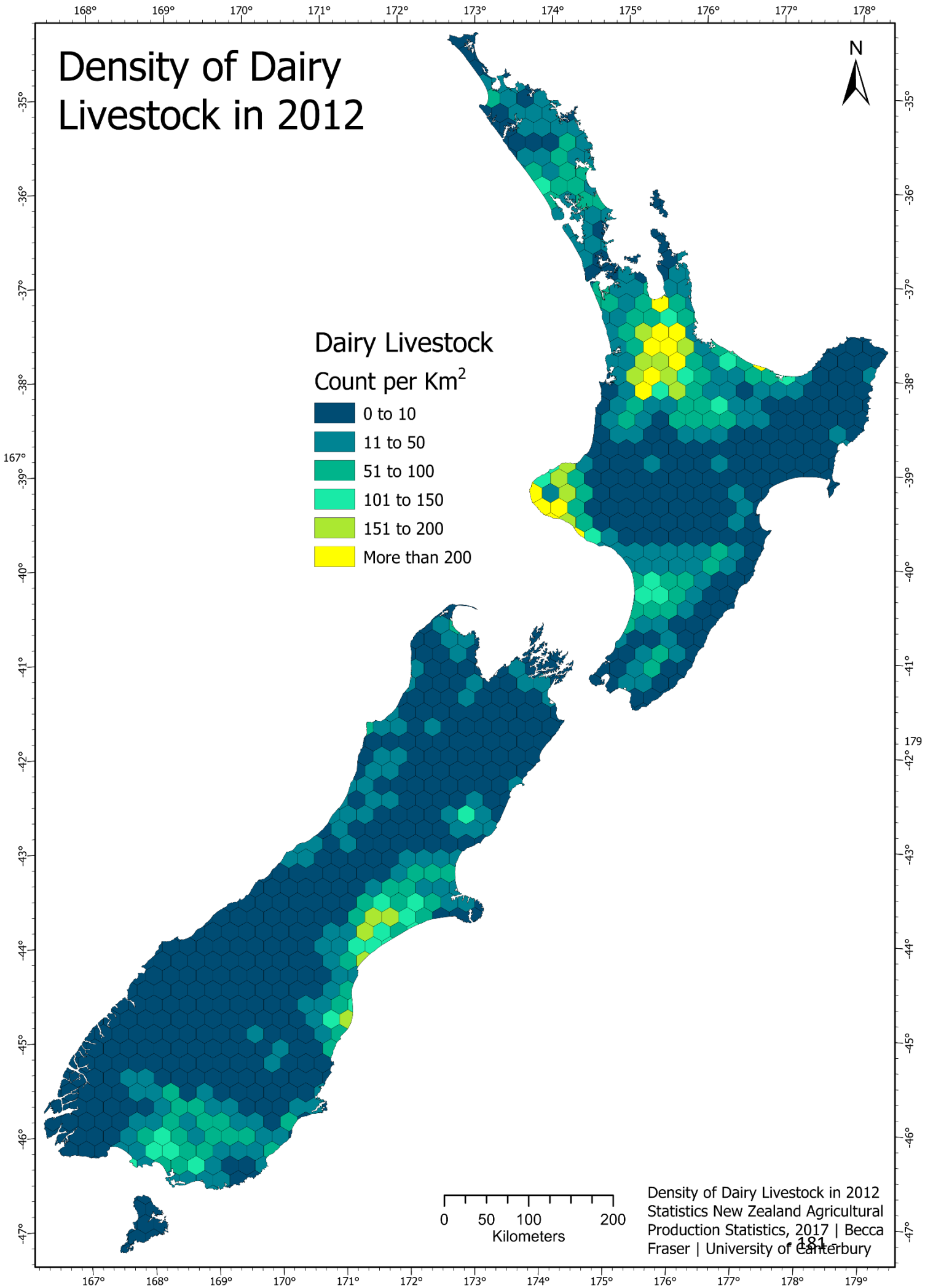
Appendix Figure C.3. Density of Beef Livestock in 2007 (Statistics New Zealand, 2018d)



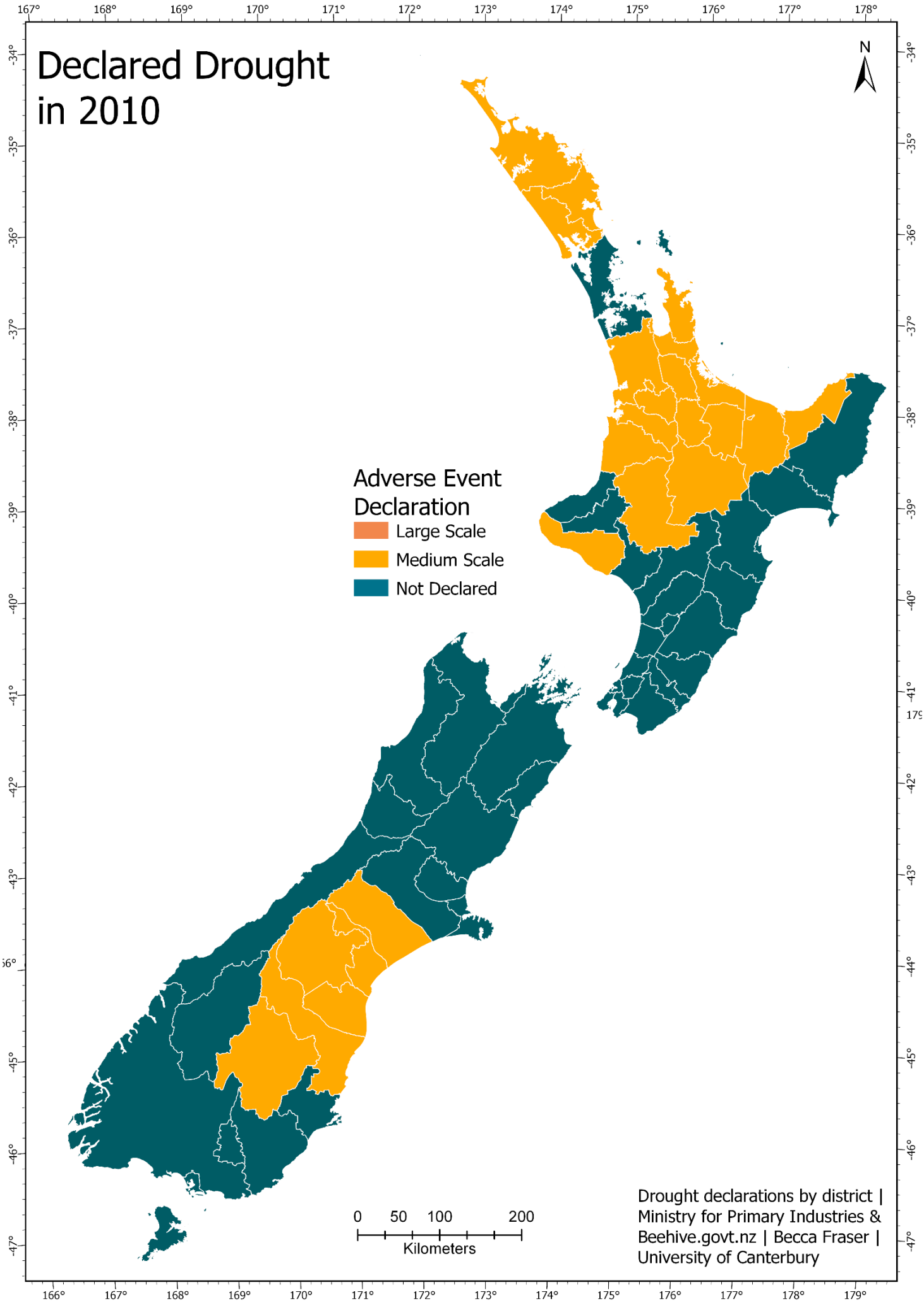
Appendix Figure C.4. Density of Beef Livestock in 2012 (Statistics New Zealand, 2018d)



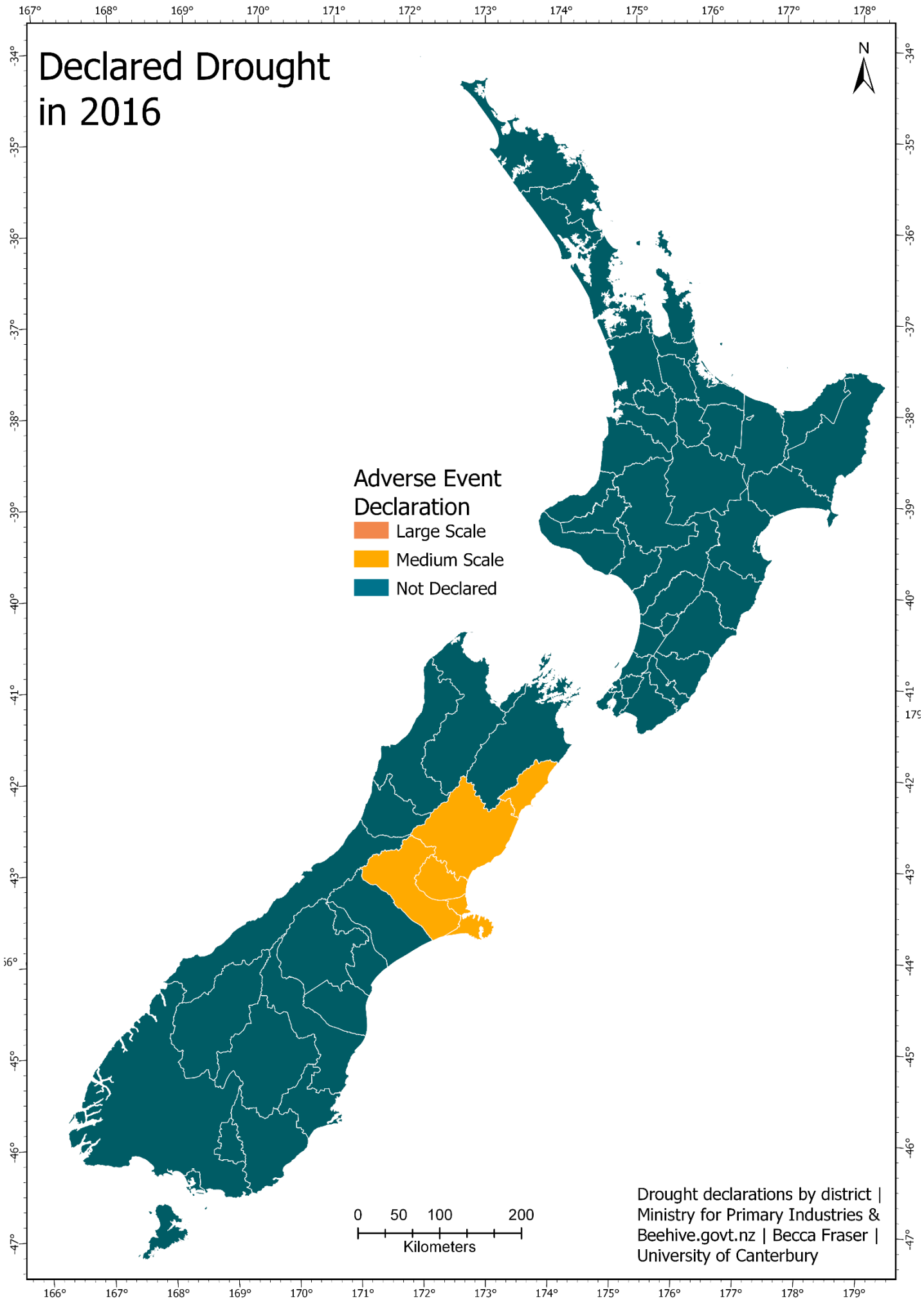
Appendix Figure C.5. Density of Dairy Livestock in 2007 (Statistics New Zealand, 2018d)



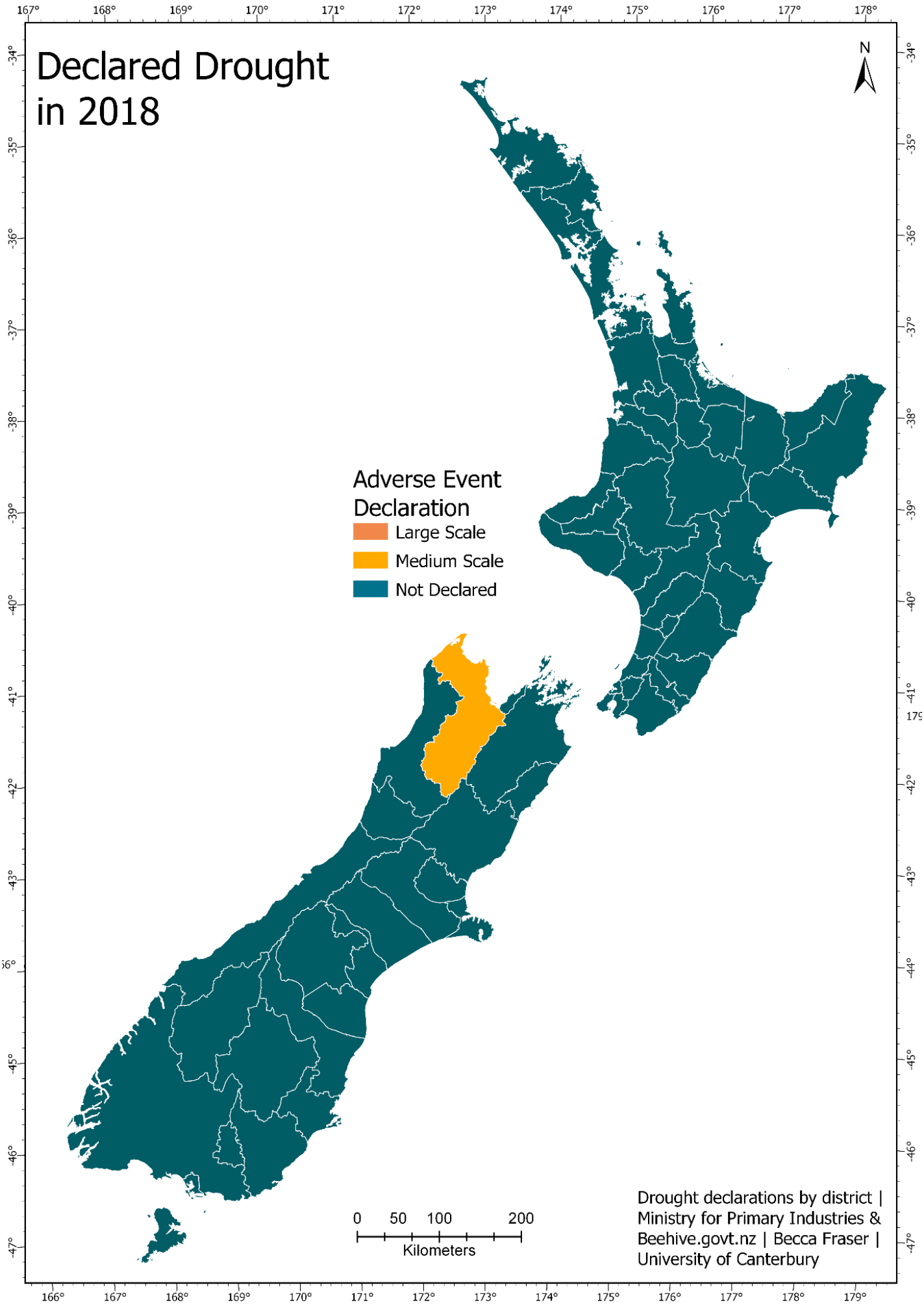
Appendix Figure C.6. Density of Dairy Livestock in 2012 (Statistics New Zealand, 2018d)



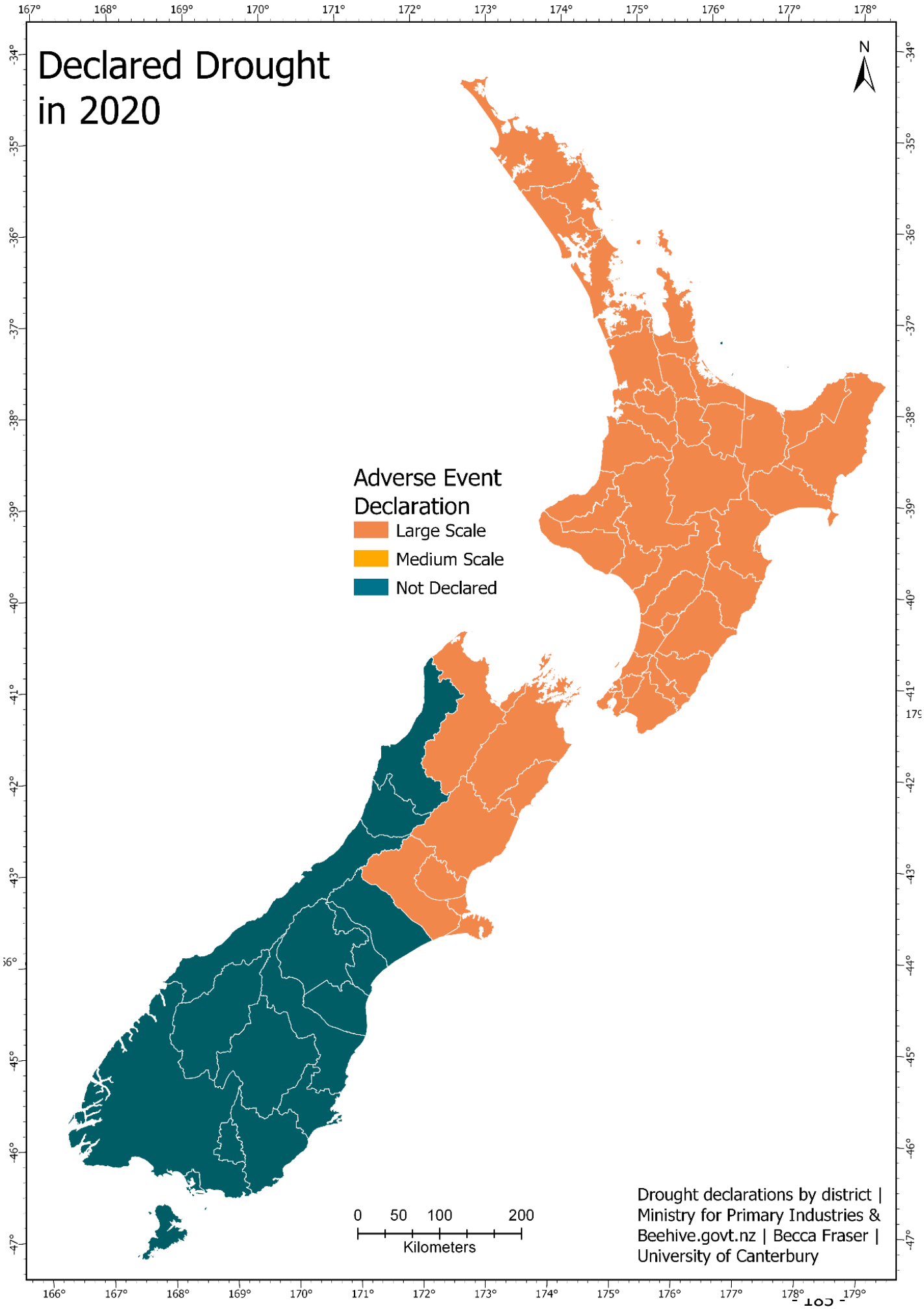
Appendix Figure C.7. Declared Drought in 2010 (Ministry for Primary Industries, & Beehive.govt.nz 2009:2018)



Appendix Figure C.8. Declared Drought in 2016 (Ministry for Primary Industries, & Beehive.govt.nz 2009:2018)



Appendix Figure C.9. Declared Drought in 2018 (Ministry for Primary Industries, & Beehive.govt.nz 2009:2018)



Appendix Figure C.10. Declared Drought in 2020 (Ministry for Primary Industries, & Beehive.govt.nz 2009:2018)